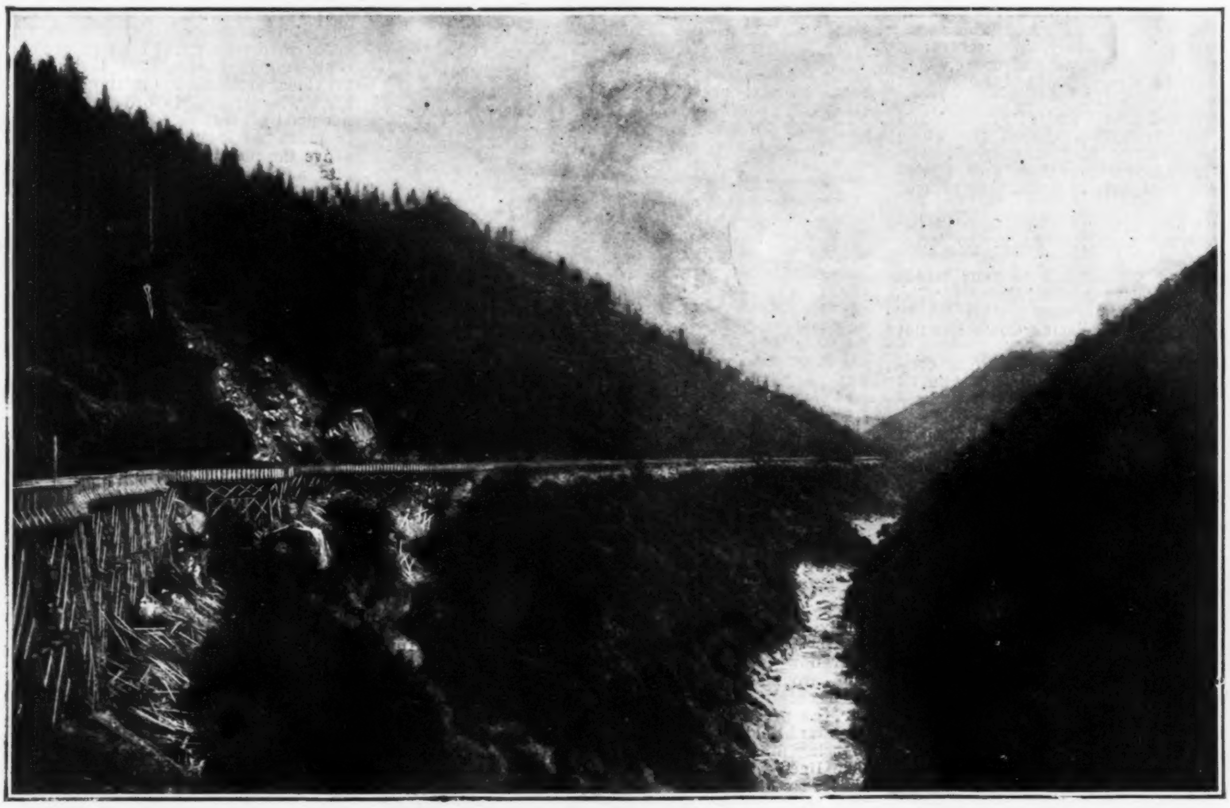
SCIENTIFIC AMERICAN SUPPLEMENT. No 1379

Scientific American. established 1845.
Scientific American Supplement. Vol. LIII. No. 1379.

NEW YORK, JUNE 7, 1902.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.



FLUME ALONG THE YUBA RIVER. FROM "POINT VIEW" A PANORAMA OF NEARLY FOUR MILES IN LENGTH CAN BE SEEN.

BIRD'S EYE VIEW OF COLGATE. THE ROAD WINDING OFF TO THE LEFT IS THAT OVER WHICH ALL SUPPLIES—EVERYTHING—COMES.

POWER PLANTS OF THE PACIFIC COAST.

THE POWER PLANTS OF THE PACIFIC COAST.*

By F. A. C. PERRINE, D.Sc.

THE frontiers are always and have ever been places where men thought and used their hands and brains to accomplish work not easy and almost incredible to the man bred under the influences of life made easy by machinery.

This is no less true in the frontiers of history and thought than in the frontiers of country and civilization.

The civilized Egyptians were frontiersmen in engineering, and accomplished buildings and pyramids which are our wonder, for though to-day their buildings would be expensive, without being difficult, it is our wonder that any race of men should have undertaken tasks so great. Greece built for all time for the reason that though she had thinkers who were creative, she had no repair shops, and she was willing, as we are not, to build so that when one piece of work was done, no one need worry over its care, but all devote their energies to planning and building better and greater. So in the history of our Pacific Coast, Capt. Lewis, a man of brain and mettle, and Lieut. Clark, a man of no less brain and mettle, but lacking what we call education, with forty-five men of like courage, stemmed the Missouri, crossed the mountains, sailed down the Columbia to its mouth on an expedition of pure scientific discovery, and returning, left in the archives of our government a report which for accuracy of scientific observation and fullness of detail has not since been excelled.

The spirit of Lewis and Clark, and of Fremont and Hayden, whose three expeditions opened the whole coast, pervades the country they discovered. The very soil seems to have taken from these men a principle which has made it capable of nourishing men of courage and resource.

In nothing is this made more evident than in the character of the electrical undertakings on the entire length of the Pacific Coast.

To emphasize this I need but call to your minds that for the past twenty years in the history of electrical engineering there has not been a time during which remarkable work on the Pacific Coast has not attracted attention.

In San Francisco was one of the first lighting companies, and one of the very first attempts by a public lighting company to light a large city on a comprehensive plan.

Power transmission at constant current was first used on the coast, when not only a 10,000-volt motor circuit was installed in San Francisco, but long-distance transmission was also actually performed in the mines with as much success as attended electrical machinery anywhere at the time, and the failure, as far as it was a failure, was due to the faults of design and manufacture of that day, while attempting problems which admitted no failure in their solution. Men's lives, as well as the financial success of such undertakings, depend on absolute continuity in mining operations. Later on long-distance single-phase alternating lighting was installed at Pomona in Southern California, and single-phase power transmission at Bodie.

Walla Walla, Wash., saw one of the first single-phase power transmission plants, and the plant at Redlands proved first the success of multiphase working. Nevada City first proved the commercial success of transmission to the mines and mine working.

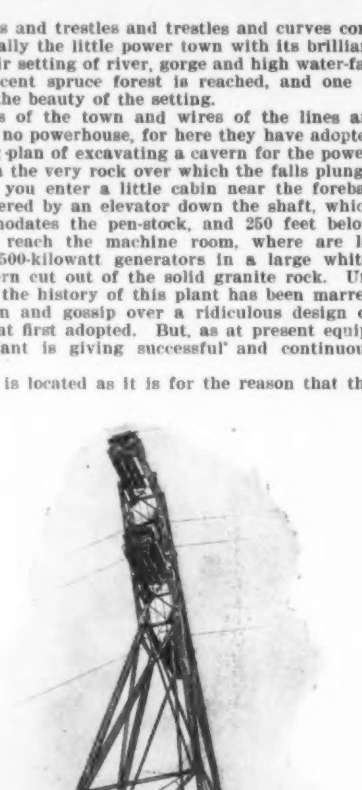
The installation of the Folsom and Portland plants are not yet forgotten, and finally we have the remarkable installations at Snoqualmie Falls, Wash., the Southern California 33,000-volt, 83-mile transmission, the Bay Counties with 144-mile transmission, and the Standard Electric Company, part of whose 154 miles of transmission, being used in connection with the Bay Counties plant, enables that company to hold the magnificent record of an actual every day transmission of over 220 miles.

We then see that the notable work on the Pacific Coast is not confined to the last few years or to any particular locality; from the north to the south, plants are scattered which merit attention and study, particularly to many of us who are not familiar with any work at all similar.

Among the plants themselves perhaps no one has attracted more attention or excited more discussion than the remarkable one at Snoqualmie Falls. Certainly no plant has a more remarkable or beautiful situation. The railroad itself which leads to this place startles one as it climbs into the Cascade Mountains, by its curves and trestles and trestles and curves combined. Finally the little power town with its brilliant lights in their setting of river, gorge and high water-fall and magnificent spruce forest is reached, and one is startled by the beauty of the setting.

The lights of the town and wires of the lines are evident, but no powerhouse, for here they have adopted the startling plan of excavating a cavern for the powerhouse within the very rock over which the falls plunge. To reach it you enter a little cabin near the forebay and are lowered by an elevator down the shaft, which also accommodates the pen-stock, and 250 feet below the surface reach the machine room, where are located six 1,500-kilowatt generators in a large white-washed cavern cut out of the solid granite rock. Unfortunately, the history of this plant has been marred by discussion and gossip over a ridiculous design of waterwheel at first adopted. But, as at present equipped, this plant is giving successful and continuous service.

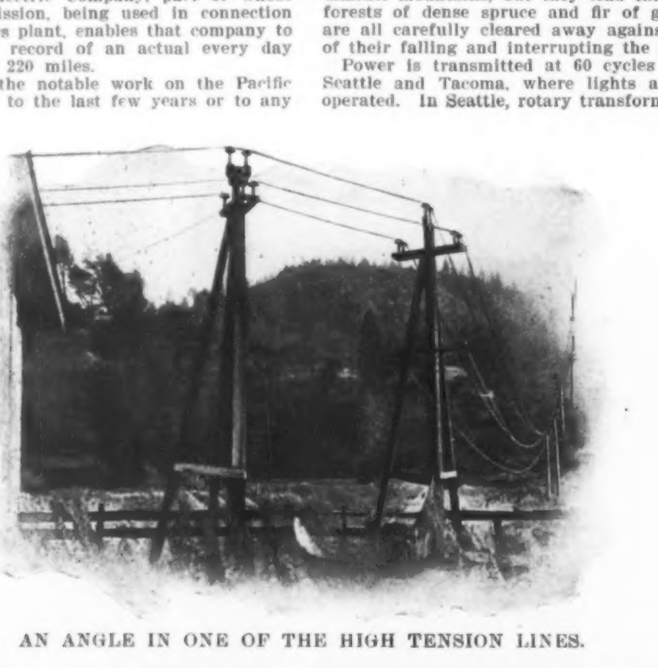
The plant is located as it is for the reason that the



THE LEANING TOWER OF THE CARQUINEZ SPAN.

spray from the falls would have made impracticable any power-house at their foot, and to have gone further down the river would have necessitated a location around a bend, to which a channel must have been cut at an expense probably greater than that for the present work. This plant disputes with the Standard Electric Company of California the honor of being first to use aluminium for transmission lines. The lines were erected at about the same time, but those of the Standard Company were the first to be put into service, and being more carefully strung were the more successful from the start. Probably no mountain lines have cost more for rights of way than those from this plant, for not only do they surmount difficult mountains, but they lead through continuous forests of dense spruce and fir of great size, which are all carefully cleared away against the possibility of their falling and interrupting the service.

Power is transmitted at 60 cycles to the cities of Seattle and Tacoma, where lights and railways are operated. In Seattle, rotary transformers are used for the conversion, but in Tacoma motor-generator sets are employed and regulation obtained by a combination of synchronous and induction motors. Much of the complaint and criticism of this plant seems to have been due to the apparent fact that there is little harmony between the seller and the largest users of power, and both the large companies at Seattle and at Tacoma are at present installing some steam in spite of the fact that at no other point on the coast is power sold at a lower rate, and that the difficulties with regulation and general service from the plant are largely chargeable to the attitude of the users of the power themselves.



AN ANGLE IN ONE OF THE HIGH TENSION LINES.

As regards the plant itself one feels compelled to admire the boldness and adaptability of the scheme.

Of course as one descends on the elevator into the cavern below the falls, the fear of something new and untried overcomes him, and the strangeness of the plan warps his judgment, but let me assure you that there is much more to admire and much less to criticise about this remarkable plant than is commonly assumed by those who have not seen it.

Turning now southward along the coast, we come to the Portland plant; remarkable not for its solution of a problem of cloudlike spray and great water pressure, but one equally difficult of a great volume of water with severely varying head.

Wherever we go on the Pacific Coast there are seasons of no superabundance of water, and in every plant there are times when efficiency must be looked to most sharply and for which the location of the wheels and their hydraulic connection be chosen. In this particular case the wheels proper for the minimum flow of water had to be located much below the surface of the maximum high-water, and furthermore, at the seasons of the great floods these falls become an almost insignificant rapid, for the reason that at this point the river is confined between narrow rocky walls which allow no over-flooded country below the falls.

It is quite obvious that no water wheel can be designed capable of operation at full load and full speed with its normal head reduced from 60 to 80 per cent, and, in consequence, large auxiliary wheels are provided, arranged for belting to the shafts of the high head wheels; and in order that the high water may not flood generators, belting and bearings, the building is made water-tight from its foundations to 3 feet above the machine floor, and the lighting of the wheel pits and belting space provided by regular marine water-tight screw port holes. The armatures of the generators are attached to the vertical shafts of the high head wheels, and while in general appearance these machines remind one of the Niagara machines, they are essentially different in revolving an internal armature in place of an external field. No attempt at parallel running is made here, but each generator feeds an independent line and supplies an independent service, some being employed in lighting and some in driving rotary converters or synchronous motors—no more than one machine being coupled to any one generator. The original transformer equipment consists of banks of small units, and in spite of the complexity of the system as a whole, the original equipment is still in service. Indeed, it is remarkable and interesting to hear the engineer whose days have been made full and whose nights have been made sleepless by this complex plant, declare that from his experience the best plant is one of independent generators and motors, and to hear him speak of machines with high inductance and almost no regulation to mention, as being in all respects the best adapted to continuous service, while to one familiar with more modern plants there is nothing so remarkable about the installation as the energy of this man who keeps it all running and giving satisfactory service. Mr. Thompson is the true pioneer operator of a pioneer transmission plant.

As we move southward into California, the power plants begin to multiply, and connected with every one is something, generally, of much interest. Many have historical importance, though most have long ceased to attract particular attention. The traveler in the mountains finds, far away from any appearance of civilization, a well-kept canal, or ditch, as these pioneer engineers would call it, and following it for a few miles, a low, constant, not unmusical note reaches his ear, and he knows that beneath his feet along the river bank lies one of those power plants, ceaselessly generating current to be used in the neighboring mines or the distant cities. Throughout the center of the State a constant type of plant prevails, and it will be of more interest to confine our attention to two most remarkable recent plants than to attempt to mention the many. The type of plant to which we refer is that of one supplied with water in a ditch varying from 5 to 50 miles in length, producing, by its combination of the rapids along the river, a head of from 300 to 1,500 feet, which is utilized with impulse wheels running at a high speed and direct connected to generators. These feed step-up transformers and the high-voltage current is transmitted for use over distances of from 5 to 200 miles and more.

(To be continued.)

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[Concluded from SUPPLEMENT No. 1378, page 22087.]

PROBLEMS OF ELECTRIC RAILWAYS.

By J. SWINBURNE and W. R. COOPER.

CONSTANT-CURRENT RAPID URBAN TRAIN.

As far as we are aware, the series constant-current system for traction was first proposed by Sir William Siemens, and was used in early days for electric tramways, but on account of its complication in this case it was abandoned. M. Blondel more recently suggested the system for electric railways, but nothing seems to have come of the proposals.*

As the system is not well known, we will give a brief description of it. Two conductors divided into sections are necessary throughout the line. In Fig 8, A_1, A_2, A_3, A_4, are sections of one of these conductors, and B_1, B_2, B_3, B_4 are sections of the other. At one end of each section there must be a switch to connect to the next section; and if a section has no train upon it, it must be short-circuited, as indicated by the dotted connections. The figure shows train T_1 and T_2 on sections A_2 and A_4. The circuit is therefore along B_1 until the motors of the train T_2 are reached. For the remainder of the section the circuit is along A_4, then through the short-circuited section A_3—B_3, through the motors of the train T_1 on the section A_2—B_2, and finally through the short-circuited section, A_1—B_1 to the generating station.

Advantages—The merits of the system may be summarized shortly:

1. The efficiency as regards loss of energy by controllers and return of energy to the line is high.
2. The all-over efficiency is high, because there is no

* Electrical World, vol. 31, pp. 21—23, 1898.

transformation between the dynamos in the generating station and the motors on the train.

3. The torque is constant, and may be so maintained as long as desired.

4. The torque may be varied at will by shunting the field, or by varying the position of the brushes.

5. The control is simple, because the current is constant and need not be large. Therefore the controlling gear is light and inexpensive. In order to get more variation of torque than may be convenient by the methods just mentioned, two motors may be used, these being placed in series at starting, and one of the motors short-circuited after a time; finally, the motors may be run in parallel, thus giving 1, ½, and ¼ as the relative values of the torque.

6. There is a marked economy of copper under certain conditions.

7. Collection of current should be simpler than with the usual parallel systems, as it is smaller.

8. High pressure in transmission is likely to be more easy to handle than by alternating current, as the dielectric is not subjected to an alternating stress. The highest pressure which M. Thury has used on his transmission lines appears to have been 22,000 volts, but there is no reason why higher should not be used.

Disadvantages.—1. The greatest difficulty is the necessity for careful insulation of the motors. With stationary motors this is a comparatively simple matter, the foundation being suitably insulated, and the shaft being insulated from anything which it is driving by a Raffard coupling or other means. The insulation would not be so simple on a locomotive, but the difficulty could probably be overcome if the constant-current system shows enough advantages.

2. Double contacts and double conductors are of course necessary, no earth return being available. These are no doubt undesirable, but they do not form a vital objection.

3. The loss due to the resistance of the line is constant, and therefore the percentage loss increases with light load; but since traction systems seldom work light, this point is not important in the case of urban railways. In main lines it can generally be kept low with a little care.

Case VI.—If we follow the same trace O F L M on a series system at constant current, the motors are taking a maximum power at F. The maximum power is a serious consideration, as it determines the size of the plant. We will therefore run with two motors in series up to 12 m/sec. and then run with a single motor at half acceleration; or we may follow exactly the same curve as our shunt machines, by weakening our fields by shunting them, so that they take constant power. As the current is constant, that means constant pressure of 2,000 volts. Taking the motors and

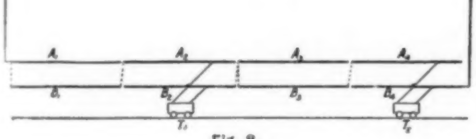


Fig. 8.

gear as having 84 per cent efficiency, at 12m/sec. (43 km. or 27 miles per hour) we get 2,000 volts and 589 amperes. From start to 12 m/sec. the motors take in 9,450 kj. (2.63 units). From 12 to 19.45 m/sec. they take 14,400 (4 units) and along the top 500, making 24,450 (6.8 units). On braking, the motor returns 9,600 (2.57 units) down to 12 m/sec., and after that returns 6,000 (1.67 units) more braking to a stop; making 15,600 (4.33 units) returned. We thus have 1.3 taken in, 0.49 wasted, and 0.83 returned. This system thus comes out considerably better even than the special shunt. But it must be remembered that that shunt system is new, and, as far as we know, nothing like it has been in use.

ORDINARY SERIES SYSTEM OF CONSTANT PRESSURE.

Case VII.—Present practice would demand series motors on the constant-pressure system with no return. The corresponding figures would then be 1.5 taken in, 1.5 wasted, 0 returned. The constant-pressure intake is 15 per cent more, and its waste more than three times.

DISTRIBUTION AND PLANT FOR RAPID URBAN SYSTEMS.

The constant-pressure system has 2,000 volts, and currents varying up to, say, 600 amperes per train. If the trains work at 2 minutes headway, allowing as margin 90 seconds per station, a train takes 24 minutes from end to end, and we may consider that 12 trains are on each line at a time, making 24 running.

The constant-pressure system has up to 2,000 volts per train, and a current of approximately 600 amperes. Such a railway would naturally be worked on the three-wire system, so we would really have 4,000 volts. There would be no sub-stations, three-phase converters, or transformers. The system of distribution for the series constant-current system requires a little more consideration. If we use a maximum of 2,000 on any train we may have a very much higher pressure in the line; for instance, we may work up to several thousand, say 10,000 volts. We would probably need to have 8,000 volts available, or even more. Each line may be worked with a maximum of 4,000 volts.

As to the station plant, the series is clearly smaller; but it is also of an unusual character. The dynamos are series-wound, driven by engines at constant torque with variable speed. Such engines are more economical and last longer. But there is a further difference. The constant-current system has little more than half the average output; and has therefore approximately half the coal consumption, but the size would be about two-thirds, for though the series trains take little more than half the energy, they take the same maximum loads, though they keep them on for a shorter time. Compared with the constant-pressure system with series motors, and no return by braking, the series system needs only about half of the plant at the generating station. An overload cannot occur on the series system. If all the trains started at once they would merely run slow till the matter righted itself.

CONSTANT PRESSURE SLOW URBAN TRAIN.

Case VIII.—We will now come to something more like present practice, and we will assume an acceleration of 0.4 m. (1.3 feet) sec.^{2} and 500 volts. As the acceleration is smaller, we will assume that the braking is not done electrically; and that the motors are series-wound, giving normal back pressure at $^2/_3$ of full speed. It is difficult to take a case from actual practice, because actual practice depends so much on the idiosyncrasies of the "train-boys." The train-boy may do almost anything in the way of wasting energy. In addition, the resistances go in steps, and it is not possible to work with constant current on a constant-pressure system. For the purposes of comparison only, we will go on with the same sort of assumptions in all cases.

If the maximum speed is taken as 43.2 km. (27 miles) per hour, the motors may be designed for full current at 8 m/sec. We need not give the calculations; the result comes out that the train absorbs 11,000 kj. (3.06 units) between stations.

Case IX.—The series-constant current system absorbs 8,500 and returns 6,050, thus wasting 2,450. The kinetic energy in both cases is 7,200. So the low-speed constant-pressure, Case VIII., takes roughly 1.5, wastes 1.5, and returns 0. Constant-current series, Case IX., takes 1.2, wastes 0.35, and returns 0.85. The time may be taken at 95 seconds. The average power taken by the parallel system is 116 kw.; by the series constant-current, 26. The maximum power of both systems is 404 kw.

The trains being slower, we may allow three minutes headway, making 16 trains running. If the system is divided into four sub-stations, the parallel will have an average output of 464 kw., and a maximum possible output of 1,616 kw. The series has an average of 104 and a maximum of 1,616, which is troublesome, but there is much less chance of the series coming up to 1,616. It would probably be safe to allow for 1,200 kw. for the parallel, and 900 kw. for the series. The parallel system must therefore handle a current of 1,200 amperes, and the series 900. It is assumed that the three-wire system is allowed with 500 volts each way, as the 1,000 volts is then between different tunnels. The series constant-current system is at a considerable disadvantage compared with the parallel in the cost of distribution. For a given maximum, such as 500 volts each way, the conductors are twice as heavy. The maximum loss is always going on in one half while the other is idle, so a lower current density should be allowed. Working with 900 amperes and allowing, say 150 amperes per square centimeter, we would need 12 square cm. extra along the railway for series, say two square inches. This amounts to nothing appreciable in the cost of the railway, and is quite insignificant in comparison with the saving of plant.

In the sub-stations the parallel system has transformers with no moving parts and converters in motion. The series system has moving converters only. As they are for smaller output than the rotary converters, they would cost about the same.

We may now summarize the results so far obtained for urban railways, first completing the table for comparison:

TABLE V.

ENERGY REQUIRED BY VARIOUS SYSTEMS (KINETIC ENERGY OF TRAIN = 1)

Case.		Maximum Power.	Mean Power.	Energy Taken.	Waste.	Returned.
I.	Series with electric braking	1,550	210	1·5	1	0·5
II.	Series without electric braking	1,035	250	1·2	1·2	0
III.	Shunt with electric braking	1,035	84	1·2	0·4	0·8
IV.	Series Constant Current with electric braking.	1,035	0	1·	0·	1
V.	Constant Pressure Rapid Urban Service ..	1,178	175	1·5	0·83	0·6
VI.	Constant Current Rapid Urban Service ..	1,178	104	1·3	0·49	0·83
VII.	Present Motor Rapid Urban Service ..	1,178	312	1·5	1·5	0
VIII.	Series Motors on Constant Pressure Slow Urban Service ..	404	116	1·5	1·5	0
IX	Constant Current Slow Urban Service ..	404	26	1·2	0·35	0·85

Cases I., II., III., and IV. are hypothetical cases for rapid urban work.

Cases V. and VI. are practical cases of rapid urban work; but the constant-pressure system, Case V., is altered by the adoption of a special shunt motor system which is not in use. In spite of that the series system, Case VI., has little more than half the average power, to give the same speed.

Case VII. is rapid urban with series motors on constant pressure and no return of energy on braking.

Cases VIII. and IX. are parallel and series for slow urban railways as at present used. The series system takes less than a quarter of the power.

Against the series system generally, it may be urged that it is untried, and demands special switch-gear, and a distributing system which has not yet been worked out.

MAIN LINES.

General Considerations.—The problem of the main line is radically different. In the first place, we have to deal with goods and mineral traffic as well as passengers, and we thus have to handle loads of widely different speeds. We also have to allow for facilities for shunting. Sidings introduce great complications in the way of electric conductors, and it is probable it would pay better to work these by steam or accumulator locomotives instead of including them in a main line network.

The working costs of steam railways for 1900 as given in Table VI. are of interest, and may be compared with those of the Central London Railway, given in Table I.

TABLE VI.

COST PER TRAIN-MILE ON STEAM RAILWAYS DURING 1900.

	Pence per train-mile.
Maintenance of way	5·69
Locomotive power	11·53
Rolling stock	3·09
Traffic expenses	11·54
General charges	1·47
Rates and taxes	2·24
Government duty	0·21
Compensations:	
Personal injuries	0·20
Damage to goods	0·31
Legal and Parliamentary expenses	0·18
Miscellaneous	0·39
Total	36·84

At first sight it will be said that the comparison is not favorable to electric traction. But there are two items which might possibly be reduced. Thus the maintenance of way would probably be less than with steam, on account of reciprocating motion being avoided, and, probably, the use of lighter locomotives or the multiple unit system. The locomotive expenses for steam traction are already less than the figure for the Central London Railway, but it must be remembered that the latter includes energy required for lifts. Consequently it is very possible that this item might be lowered by electric traction. It is impossible to compare the costs of traffic expenses, because the conditions are very different. Possibly this item might be reduced to some slight extent.

Summing up, we may say that, although an increase of traffic would result on the suburban parts of a main line by the adoption of electric traction, it does not follow that there would be a large increase on main lines proper. The success of electric traction on main lines must therefore depend largely on a reduction of running cost. In other words, the question of all-over efficiency of distribution is much more important on main than on urban lines.

It must be remembered that we have about reached the limit of speed of steam-drawn trains. Our gage is unfortunately less than modern railway engineering demands, and it is impossible to alter it now. The tunnels and bridges also cramp us. Electric equipment, however, gives us as much power as we can want on a train of present height and gage, and in addition gives it with steady running. The first demand on long lines to be met electrically will probably be rapid expresses, and it is with that in view that we have taken 1,000 kilowatts as supplied to each train.

Saving of energy during acceleration and its return while braking are no longer of paramount importance. The parallel system, therefore, seems to have the advantage in every way. There are, however, two factors which come in its way. In long distance railway work the maximum power is needed at the highest speeds. Either system can be designed to supply that; but the parallel has less flexibility as to speed. The three-phase system is most unfortunate in this respect, for its proper speed is perfectly definite. The series constant current system gives a perfect solution of the problem. The motors give the maximum torque normally even at the highest speed. If a lower speed is needed, one motor is used, giving half the torque; or two motors in parallel, giving a quarter of the torque. By alternating from one arrangement to the other any speed can be obtained economically. Shunting the fields gives a further adjustment.

There is another question to be considered, and that refers to the limits of pressure. Shunt motors cannot well be made for high pressures. Whether series or shunt, there is next the difficulty as to the pressure possible on the commutator. We can hardly utilize a higher pressure than 2,000 volts on the constant-pressure system. On the constant-current series system, as long as we do not have more than 2,000 volts per machine, or 4,000 per train if we have two motors, there is no limit to the pressure that can be used. It must be remembered that if there are two motors in each case the series constant current system can always have twice the pressure of the constant pressure, as in this system the motors are in parallel on the full pressure, while in the constant current series system the motors are only in parallel on low pressures.

We may take a passenger train as needing 1,000 kilowatts at its maximum speed. This is more than is used at present; but there can be little doubt that higher speeds will be adopted as soon as they can be obtained. The power here is used to overcome traction resistance, not to get up speed or kinetic energy, only to be dissipated again almost immediately. We may for the present discuss 1,000 kilowatts, which is roughly half as much again as the power of an express engine.

CONSTANT PRESSURE MAIN LINE.

We may thus take it that we have to supply 2,000 volts and 500 amperes per train. Though the traffic near the terminus may be considerably greater, we will take only from two to three trains an hour as a fair average. They will naturally be thickest when slow. If they are going at only 64 kilometers (40 miles) per hour, we have 3,000 kilowatts to be supplied every 64 kilometers for each line. At this rate we have sub-stations every 128 kilometers, we have to transmit our power up to 64 kilometers on each side of each sub-station. This, at 105 amperes per square centimeter means 10 square centimeters of copper for each line, tapering down, or an average of 5, or less than a square inch. This costs for copper only £270 per kilometer (£430 per mile) per track. If we double

the area of the conductors we have a maximum drop of 400 volts, and a mean drop of perhaps 100 in ordinary traffic. It would thus be easy to arrange for sub-stations every 64 kilometers or so; but we have assumed the three-wire system with 2,000 volts a side. It may be more prudent to limit the distance to something like 40 or 50 kilometers. Unless the distances can be great enough to enable distribution to be carried out from the generating stations themselves, there is not very much point in having the sub-stations very far apart. The generating stations should be at places where they can sell energy for industrial purposes, so as to get good load-factors and large outputs. At present this means near large manufacturing towns. Some day people may realize that the way to deal with the congestion of large cities is not to provide more and more facilities for people to get into them, but to move the factories out of them.* A power-station on a main line in the country where the railway crosses a river would be a good nucleus for a new industrial city on sound principles. On the other hand, as Mr. Highfield has pointed out, producer gas-engines may be used to work rather numerous generating stations, the gas being supplied by pipes.

SERIES MAIN LINE.

The series system has the advantage of doing away with the sub-stations. The constant pressure example had a current varying from 1,500 down to 0 along the line. For series work it would be quite reasonable to take a current of, say, 500 amperes. This needs 2,000 volts per train; so for 8,000 volts, with earthed middle, that is, 4,000 each way, we can run four trains on each line on each side of the station. If the trains have a speed of 64 k/h. as before, and a headway of 20 minutes, we have a distance of 85 kilometers on each side of the station, or no less than 170 kilometers (or 106 miles) between stations. To keep the maximum loss in leads down to 1,000 volts we would need a current density of about 75 amp./cm², and for 500 amperes this means 6.6 square centimeters, or roughly a square inch of copper each way. Taking the density of copper as 9, we need $6.6 \times 9/10 = 6$ tonnes of copper per kilometer and another 6 for return, or £720 a kilometer, or £1,150 a mile for copper for each track. The series thus gets over the difficulties of the sub-stations altogether. It has, of course, many disadvantages. The collection is more difficult, as the current is greater and there must be double collectors. The problem of collecting is not dealt with in this paper; but that is by no means because it is not real; it is rather because there is no solution to offer. It may prove very difficult to collect 500 amperes at 120 kilometers or 75 miles an hour.

It is difficult to foresee the development of gas-engines, and it is therefore impossible to say whether large engines will be best at constant speed and varying load, or constant torque and varying speed. Constant speed may be good in certain cases, but a fast train cannot run at a maximum speed over all parts of the line alike, and the variation that is necessary for fast is not needed for slow trains.

OTHER SYSTEMS.

The author then briefly referred to other possible systems. As to the three-phase constant pressure system, he said that as to efficiency, it is nearly on a par with the shunt system, in which the normal output of the motors is at full speed instead of about two thirds of it. It is thus behind the direct current as commonly used, and far behind such a direct current system as Case IV. The energy is also returned with a low power-factor, which is a very serious drawback. For long railways it has many advantages. The disadvantages are three collectors, constant inflexible speed, and complication.

CONCLUSION.

Our aim has been to treat the electric railway as if it were a completely new problem in which nothing had been done, and to review as many different ways of meeting the difficulties as could be thought of for the purposes of the paper.

The paper may be broadly summed up as indicating reasons for holding that the treatment of railways as if they were tramways is bad, and that even in short low-speed urban railways a particular shunt system would be considerably better than present practice. Series constant current, it is urged, is better still.

For long railways it is important to have the same system as short urban or suburban lines, as the systems will be connected. Long lines are thus influenced by suburban and short full-sized urban lines, but not necessarily by tubes, as they will most likely be independent. It is quite satisfactory, therefore, to have one system for small-bore railways and another for full-sized. Whether the series is the best solution for urban and main line railways, if they must have the same system, is another matter.

The main problem of electric railways is to get varying speed from constant pressure. The electric method of doing this with two extra machines is clumsy and inefficient. A mechanical variable speed gear would be of incalculable advantage, but it is not easy to design one fit for locomotive work.

The special shunt direct-current arrangement with weak fields solves the difficulty to some extent, but it involves rotary transformers or dynamotors at the sub-stations.

In considering the expense of stations and sub-stations it should be borne in mind that they will also be signaling centers. If the trains are worked electrically, the power can be cut off without communicating with the driver, and the driver will have no need of signals. In some of the systems sketched in this paper it is easy to signal the exact position of all the trains to the sub-station or station. Models will then move along plans of the railway, so that the trains are controlled entirely from on shore, so to speak. All the driver has to do is to keep a lookout for anything on the line. He also has to start and stop at stations. As the ordinary signaling will be replaced, there will no doubt be a telephone wire along the railway with call-boxes at intervals. In case, say, of accident, such, for instance, as a landslip, the difficulty of stopping a train that is due will not exist. Anyone can communicate to the station, and the train will be stopped.

The present chaotic demoralization of suburban railways by fogs will not exist at all. It will be as easy to run in fogs as in the dark.

But we shall not reach all these perfections very soon unless we look where we are going.

* Madgen, J. Soc. Arts, Febuary, 1902.

A STUDY OF GROWING CRYSTALS BY INSTANTANEOUS PHOTOMICROGRAPHY.*

By THEODORE WILLIAM RICHARDS and EBENEZER HENRY ARCHIBALD.

COUNTLESS observers have watched the growth of crystals under the microscope. As long ago as 1839 attempts were made to study also the birth of crystals, in order to determine in what manner the new phase makes its entrance into the system. With a microscope magnifying 600 diameters, Link† thought he could detect the formation of minute globules at the moment of precipitation—globules which soon joined and assumed crystalline form. Schmidt,‡ Frankenheim,§ and especially Vogelsand,|| made similar observations some years later, and several more recent accounts of this phenomenon have appeared. Modern investigators have been more concerned with the speed of separation from supersaturated or supercooled liquids than with the form of the first separation.*

Ostwald, in 1891, accepted the interpretation of these data which assumes that crystallization is always preceded by the separation of an initially liquid phase, consisting of a supersaturated solution of the former solvent in its former solute.†

This explanation is indeed a plausible one, and undoubtedly holds true in cases like those studied by Schmidt and Vogelsang, where a substance separates at a temperature not far below its melting point, and often where a substance soluble in one liquid is precipitated by the addition of a consolute liquid in which the substance is insoluble. For example, phenol always separates from its aqueous solution in the form of a liquid, and manganous sulphate forms at first two liquid phases when alcohol is added to its aqueous solution. On the other hand, the separation of a high-melting salt like baric chloride from its solution in pure water is much less likely to take place in this way. In the absence of data, the behavior of such a system is rather a matter for speculation than a question to be decided by reasoning.

Ostwald has shown that an exceedingly small particle of solid is capable of starting crystallization,‡ a fact which may not be wholly foreign to the present discussion.

In any case, the matter seemed worthy of further experimenting. Oswald says: "Die erste Bildung der Krystalle lässt sich bei Salzlösungen und dergleichen microscopisch nicht verfolgen, weil gewöhnlich im Gesichtsfeld an einer bislang gleichförmigen Stelle plötzlich ein Kryställchen erscheint." While this is true as far as the human eye is concerned, instantaneous photography, an art unknown in Link's time, seemed peculiarly fitted for the unprejudiced recording of the circumstances attending the genesis of crystals. An attempt in this direction is described below.

The problem resolved itself into the taking of a number of successive instantaneous microphotographs of a suitable mixture at the point of crystallization. This problem presented some difficulties, however. In order to secure a sufficiently brief exposure very great

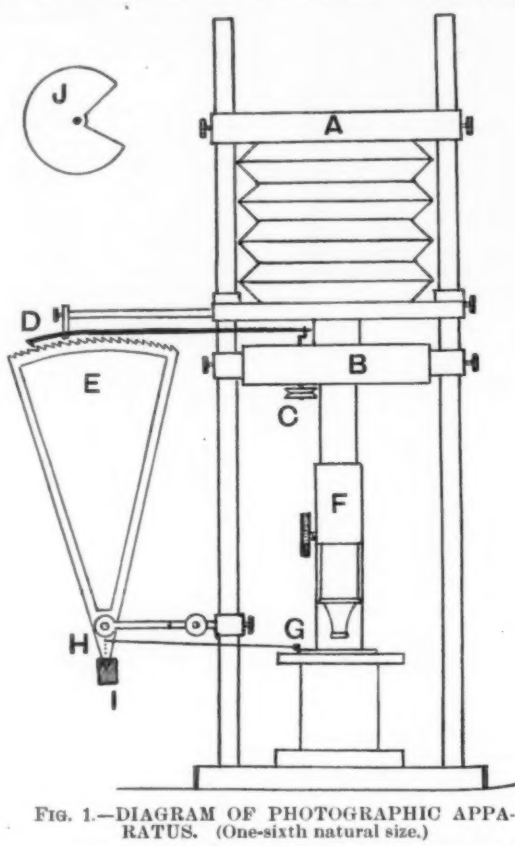


FIG. 1.—DIAGRAM OF PHOTOGRAPHIC APPARATUS. (One-sixth natural size.)

A, sensitive plate or film holder; B, box containing shutter; C, pulley attached to axle of shutter to communicate power from motor; D, light rod moved by crank attachedto same axle; D is guided by a stoutsupport in which it moves loosely; E, segment provided with ratchet teeth, moved gradually by rod D; F, microscope; G, slide for object, moved by wire running to H; H, holes to regulate amplitude of object's motion; I, weight, balancing segment; J, horizontal projection of revolving shutter in detail.

FIG. 2.—SODIC NITRATE; 110 DIAM.; EXPOSURE 0.12 SECOND.

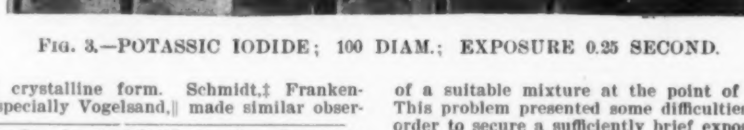


FIG. 3.—POTASSIC IODIDE; 100 DIAM.; EXPOSURE 0.25 SECOND.

* Reprinted from Proc. Am. Acad. 36, 341; Am. Chem. Jour. 26, 61; Phil. Mag. (Nov. 1901), 488. The photographs herewith published are kindly lent by the American Academy of Arts and Sciences.

† Pogg. Ann., 46, 258 (1839).

‡ Ann. Chem. (Liebig). 53, 171 (1845).

§ Pogg. Ann., 111, 1 (1860).

|| Die Krystalliten (Bonn, 1875). See Lehmann, Molecularphysik, I, p. 730 (1888).

* Gernez: Compt. Rend., 95, 1278 (1882); Moore: Ztschr. Phys. Chem., 12, 545 (1893); Friedlander and Tammann: Ibid., 24, 152 (1897); Tammann: Ibid., 25, 441; 26, 307; 367; 28, 96; Kuster: Ibid., 25, 480; 27, 222; Bogajavlensky: Ibid., 27, 585.

† "Lehrbuch," I, 1039 (1891).

‡ Ostwald: Ztschr. Phys. Chem., 22, 289 (1897).

illumination is needed. The greater the magnifying power of the lenses of the microscope-camera, the more intense must be the source of light. The difficulty is increased by the fact that most crystals are so transparent as to absorb but little light, and reflection is possible only in certain directions. Hence it is hard to obtain a distinct image even in a strong light. Moreover, the machinery necessary for shifting the plates must be so frictionless in construction, and so firmly fixed, as to impart no vibration to the camera or the mobile subject of study.

These difficulties were at least partially overcome by two different arrangements, the first of which caused the successive impression of a bright image in a dark field, and the second registered dark images in a succession of bright fields. Obviously the former was the more economical as regards expenditure of sensitized film, and the simpler in execution; for when the field is dark successive images can be obtained by a very slight motion of either object or film, while, when the field is light, the whole previously exposed surface must be replaced by a fresh surface before each exposure.

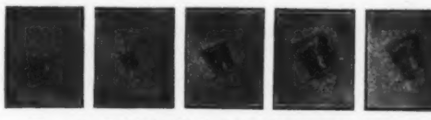


FIG. 4.—POTASSIC IODIDE; 580 DIAM.; EXPOSURE 0.17 SECOND.

FIG. 5.—POTASSIC IODIDE; 580 DIAM.; EXPOSURE 0.25 SECOND.

FIG. 6.—POTASSIC IODIDE; 580 DIAM.; EXPOSURE 0.17 SECOND.

FIG. 7.—POTASSIC IODIDE; 580 DIAM.; EXPOSURE 0.17 SECOND.

The apparatus consisted of a good compound microscope fitted above with a vertical folding camera, which was supported by two massive steel pillars on the heavy stand. It was, in short, the regular photomicrographic outfit made by Bausch and Lomb. Between the microscope and camera, in a suitable light-tight box, was placed a revolving shutter, which allowed an exposure equal to one-fifth of the time of its revolution. Thus, when the shutter made two revolutions in a second, the exposure was one-tenth of a second. A Henrici hot-air motor, combined with speed-reducing double pulleys, enabled the experimenter to use any rate of revolution desired. The rate was reasonably constant, but no attempt was made to make it absolutely so. The sensitive plate or gelatin film was held above in a suitable holder, which was put in the place of the ground-glass plate used for focusing just before each series of exposures.

In carrying out the first of the two methods it was found more convenient to move the crystallizing solution than to move the photographic plate. For this purpose the slide bearing the drop of liquid was attached by a wire to a point just below the center of a segment provided above with saw teeth. The segment was moved gradually by the oscillating motion of a connecting rod, fastened by a crank to the revolving shutter at one end and playing into the saw teeth on the other. In order to make the motion certain, the stroke of the connecting rod slightly exceeded the distance between the saw teeth. The segment was suspended in such a way that its center of gravity coincided with its point of support, and the friction of its bearings was so adjusted that it would move easily, and yet remain stationary during the return stroke. The distance through which the observed object was moved was easily varied by altering the relative lengths of the lever-arms; distances varying from one-tenth to one-fiftieth mm. were generally used. The shutter was so arranged that during the exposure the segment and slide were at rest, the shift in position being effected during the four-fifths of the revolution through which the shutter was closed. The accompanying diagram will make the arrangement clearer.

The diagram represents the apparatus an instant before an exposure begins.

As a source of light any ordinary combination of incandescent electric lights proved to be inadequate. A good Auer von Welsbach light with a powerful reflector was more satisfactory, but the best results were obtained with the help of sunlight directed by a suitably arranged mirror and condensed by reflectors and lenses. The chief, though not serious, difficulty of this arrangement was the great heat caused by the converging rays, a difficulty which was obviated partially by an absorbent screen in some later experiments.*

The first photographs were taken by reflected light, the drop of solution being placed upon a ruby-colored slide. As soon as the crystallization had begun upon one edge of this drop the very sensitive plate was uncovered and the shutter and segment were set in motion. The exposure was stopped after 15 or 20 revolutions, so as to avoid confusing superpositions. Even with the strongest light the images were very faint and unsatisfactory; it is not worth the space to reproduce them here.

Another mode of obtaining light images on a dark ground, applicable to all except the isometric system of crystals, is the use of polarized light.† A Nicol prism was placed in the barrel of the microscope and another just below the stage. The main body of the light was thus intercepted by the crossed prisms, and only that which had been deflected by the crystalline structure was allowed to emerge. It is true that this method could not, in all probability, decide the chief point at issue; for the prenatal globular condition of crystals would probably have no effect on polarized light. Definite optical structure is of course necessary to produce the required deflection of the plane of polarization, and such definite structure might not be possessed by the globules. Nevertheless, the idea seemed well worth a trial.

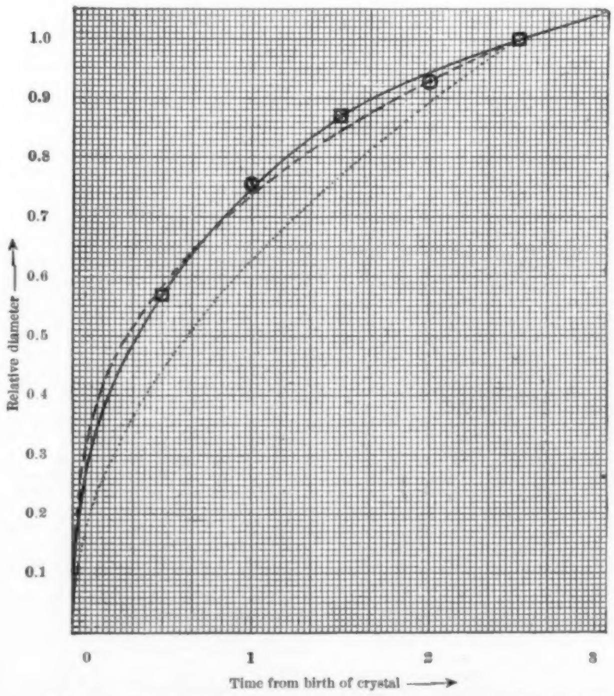


FIG. 8.—DIAGRAM REPRESENTING RATE OF INCREASE IN CRYSTAL DIAMETER.

□ represents point from average of crystals taken at random.
○ represents point from average of selected crystals.
—— represents probable actual rate of growth.
- - - represents equation $D^3=kt$.
...... represents equation $D^2=kt$.
The unit of time is the time of one revolution of the shutter, or 1.25 seconds.
The substance was potassic iodide.

The images were now much more clearly defined and striking, and with a magnification of 30 diameters, 10 sharp impressions, each exposed one-fiftieth second, could be obtained in a second. For this low power the eyepiece was removed from the microscope and an objective with long focal distance alone was used to give the image. The degree of enlargement was obtained by actually measuring the image of a micrometer scale divided into 0.1 mm. The rapidity of exposure was so great that many plates were sacrificed, for it was difficult to find the precise moment when nascent crystals were in the field of view. In most cases the crystallization was already too far advanced when the exposure began, but in some nothing but blank negatives were obtained. The best method is so to arrange circumstances as to have the crystallization begin upon one edge and spread slowly over the drop. Another difficulty was the attaining of the exact actinic focus, which differed slightly from the visual focus. It was found that a definite fraction of a revolution in the fine adjustment of the instrument or a definite shift of the sensitive plate could be relied upon to cover this difference, when experiment had once found the right spot. Of course an apochromatic lens would have saved us this trouble, but our device answered sufficiently well and was less expensive. Such lack of definition as may be observed in the plates was due rather to the behavior of the object than to optical imperfection.

Among other substances sodic nitrate, baric chloride, cupric sulphate, and ferrous ammonic sulphate were found to give satisfactory results.

All the images recorded on these plates were perfectly sharp and regular when in focus; but the magnifying power was too low to give important evidence concerning the birth of the crystals. The crystals always first appeared as points, indicating a diameter of less than 1-300 mm. The regularity of growth of those already well started is worth a passing mention.

The next objective used gave a magnification of 110 diameters. With this power the light was so much diminished that exposures of less than one-fifteenth second became too pale. An example from among these negatives is given. It will be noticed that in all cases the crystals have their regular forms when they first appear upon the plate. Another point worthy of attention is the fact that the growth in diameter at first is more rapid than it seems to be subsequently. This rapid growth of small particles has already been noticed by Ostwald;* it is treated more fully in the following pages. The crystals of sodic nitrate grew faster than those of baric chloride or cupric sulphate, and in some cases the crystals evidently appeared at first in very thin plates. It is interesting to note that the thickening of these plates caused a corresponding change in the quality of the emerging light, and hence the crystal images show a rhythm of dark and light. (Uppermost crystals, Fig. 2.)

At this point the whole method of procedure was changed on account of the probability that a globular condition, if it existed at all, would not be visible through the crossed Nicols. The apparatus was now arranged for the exposure of successive portions of a film to unpolarized sunlight emanating from a bright field, upon which the crystals appeared as dark spots. The slide and crystallizing solution were allowed to remain stationary, and the gelatin film was moved, as it is in the common film-cameras. The 2.5-inch Eastman cartridge film was found to answer the purpose. At first the turning was effected by an automatic electromagnetic arrangement which received its current from a make-and-break contact attached to the shutter. Since a current of 10 amperes was needed to secure a sufficiently forcible and speedy action, the operation of this device was somewhat troublesome, and when the exposures were not much more frequent than one a second the film was rolled by hand. A suitable signal attached to the shutter axle, which was still turned by the Henrici motor, gave the necessary indication of the proper moment for renewing the sensitive surface. With this apparatus it was of course possible to obtain photographs of isometric crystals, which could not be examined with the preceding arrangement.

At first a power of 100 diameters was employed, and very satisfactory pictures of the growth of crystals of potassic iodide were obtained. One of these negatives is reproduced here as an example (Fig. 3). They showed nothing new, however; hence a much higher power of 580 diameters was applied by combining a 2-inch eye-piece with a ⅛-inch objective. With this contrivance the light was, of course, far less intense, and the definition less sharp. Even with the brightest sunlight, concentrated by mirrors and an Abbe condenser, the exposure could not profitably be made less than one-eighth second. These plates have been enlarged by usual processes to over seven times their original size, so that a total enlargement of over 4,000 diameters has been attained. Since these larger images were not much more clear

* Hutchins has shown that pure water is as good as a solution of alum for this purpose (Am. J. Sci., 143, 526 (1892).

† This suggestion was kindly made by Prof. E. C. Pickering.

* Ztschr. phys. Chem., 22, 330.

than the smaller ones, while they occupy much more space, the plates herewith given are all from the original negatives.

A number of good impressions of crystallizing potassic iodide were taken under these circumstances, but many other rolls were sacrificed. The chief difficulty, as before, was to secure the right moment, and this difficulty was, of course, much augmented by the limited expanse of the field. Prints from a few of the successful negatives are given. In order to give a clear impression in printer's ink, these were much intensified by successive photographic printing and intensification; but, of course, no attempt was made to remove the imperfections of the successive plates, for which allowance may easily be made (Figs. 4 to 7).

The study of these photographs reveals several interesting points. In the first place, it is noticeable that no image is wholly without evidence of crystalline structure. The most doubtful cases are those in Figs. 3 and 5; but the elongated shape of these doubtful images seems to indicate a solid. A globule of a new liquid phase, 1-1,000 mm. in diameter, would have left an unmistakably circular image on the highly magnified plate, for its index of refraction could not have been identical with that of the aqueous solution. The fact that we could not find such a globule, of course, does not prove that a globule cannot exist, either for an infinitesimally brief period of time, or of an infinitesimal magnitude beyond the reach of microscopic observation. Nevertheless, so many scores of photographs were taken as to diminish considerably the probability that such globules can ever be seen with substances possessing a high melting-point.

A striking fact to be noticed in nearly all the most highly magnified records is the ill-defined appearance of the smallest crystals. This appears to be due, not to a lack of structure, but rather to the rapid growth in diameter, which is manifest in the young crystal. The initial rapidity is so great that the fifth of a second appears to include several different stages of growth, and hence a blurred impression results. It is easy to obtain some idea of the rapidity of this initial growth by comparing the sizes of the first two or three appearances of each crystal.

With this object a few of the series were measured by means of an accurate micrometer; but the conditions of the experiments are too uncertain to give the very precise measurements much value. Perfect constancy of temperature and evaporation, as well as in the rate of the revolving shutter, involving grave complications in the apparatus, should of course be maintained if great accuracy is attempted. Measurements with a fine millimeter scale afford all the precision which it is worth while to attain under present conditions. A typical case (potassic iodide, largest crystal) gave the following measurements in millimeters for the successive longest diameters: 2.0, 2.6, 3.0, 3.2, 3.3, 3.5, 3.7, 3.9, 4.1 4.2, 4.4. The actual sizes of the crystals were, of course, only a hundredth of these measurements, since the enlargement was 100 diameters.

In spite of the inexact nature of such measurements, it is possible to use them as a means of defining approximately the law regulating the changes in speed. The following table details six series of corresponding diametric measurements of six crystals taken at random. The measurements were taken directly from the photographs in millimeters.

DIAMETERS OF SUCCESSIVE IMAGES.

	Crystal 1.	Crystal 2.	Crystal 3.	Crystal 4.	Crystal 5.	Crystal 6.
First appearance	1.0	2.0	3.0	3.0	4.0	2.5
Second "	1.6	2.6	5.7	6.0	6.7	3.5
Third "	1.7	3.0	6.8	7.0	7.8	4.1

These all show greater growth in the first interval than in the second. In order to reduce them to one standard, the diameter of the third appearance was taken in each case as unity. The table then becomes:

DIAMETERS OF SUCCESSIVE IMAGES.

	Crystal 1.	Crystal 2.	Crystal 3.	Crystal 4.	Crystal 5.	Crystal 6.	Average.
First appearance	0.59	0.67	0.44	0.43	0.51	0.61	0.54
Second "	0.94	0.87	0.84	0.86	0.86	0.85	0.87
Third "	1.00	1.00	1.00	1.00	1.00	1.00	1.00

At the time of the first appearance the average age of the crystal must be about half the time intervening between two exposures; for the crystal must have been formed since the last exposure, and it is as likely to come near the beginning as near the end of the interval. Thus in Fig. 5 the crystals evidently started immediately after the previous exposure, while in Fig. 3 they were registered while still very young. The averaging of a much larger number of observed diameters led to the slightly different values given below, corresponding to the accompanying times:

Time=t.	Diameter=D.
0 interval	Diameter 0
0.50 "	" 0.57
1.50 intervals	" 0.87
2.50 "	" 1.00

These data are plotted in Fig. 8.

The inspection of the figure shows at once that the curve is similar in general shape to one represented by the equation $D^n = kt$, where D is the diameter of the crystal, t the time from the birth of the crystal, and k a constant. The only question is as to the magnitude of n. The curves which result from the assumptions $n = 2$ and $n = 3$ are given, for comparison with the experimental curve. It is clear that the curve with the latter value, $n = 3$, is the nearest, possessing the same general curvature, and deviating from the average less than the individual measurements do. This is equivalent to saying that *equal increments of time correspond to equal increments of volume*, instead of equal increments of *surface*, as one might have supposed. Of course a law based upon such merely approximate data cannot be considered as definitely settled; but clearly the general character or tendency of the curve is established. It is probable that under the necessarily ill-defined conditions of our experiments the growth follows no one law with precision; supersaturation, convection, diffusion, and evaporation must all influence the result. The crystal which seems to have deviated most widely from the average is that depicted in Fig. 4; this crystal grew at first less rapidly than usual, and finally came almost to a standstill. It is possible that an increasing solubility due to increasing temperature may have caused this delaying tendency.

It is interesting to compare this average, calculated on the assumption that the crystal starts in the middle of the dark interval, with a few single cases which appear to have begun to crystallize very near the beginning or end of the interval. In these cases, the first image of the crystal will appear either almost as large as the second image, or very small compared with it. It will appear almost as large as the second image when the preceding exposure has just not caught the beginning of the crystal, which has thus had a whole interval for growth; or very much smaller than the second image when the first impression has registered a crystal only a very small fraction of a second old. Marked examples of the former case are to be found in Fig. 5, and of the latter in the largest crystal in Fig. 3, and the smallest crystal in Fig. 7. The times of revolution represented by Figs. 3 and 5 are the same, 0.25 second, and the other conditions also were identical, hence we may compare these with accuracy. Careful measurements of the sizes in Fig. 3 showed the first large impression of the crystals to be about 80 per cent of the diameter of the next impression, and approximately the same relationship appears in Fig. 5. In order to find if this relationship corresponds with the equation $D^3 = kt$, the larger diameter is assumed to be 0.93, the theoretical value corresponding to two intervals of time, if that corresponding to two and one-half intervals is taken as unity. Hence the smaller one becomes 0.75, corresponding to one interval of time, a value, marked in a circle on the diagram, which is surprisingly near the cubic curve. Hence the equation $D^3 = kt$ is confirmed. That the same curve holds approximately for the further growth of the crystal is manifest by a quantitative study of Fig. 3.

In this connection it is interesting to note that the crystal seems often to grow at first in the same proportion in all directions. Even the very minute image in the center of the second exposure, given in Fig. 3, shows itself under the microscope to be elongated like the crystal which grows from it. In the next exposure this crystal had the proportions 0.02 mm. × 0.0125 mm., and after four more exposures it still had almost exactly the same proportions, being 0.035 mm. × 0.022 mm. After two or three more seconds the form given in Fig. 3 began to change slightly, the crystal becoming slightly less elongated in shape; but by this time the neighboring crystals had grown so much as to approach it, and hence to alter the conditions. A similar constancy in proportion may be observed in many other series here given.

The diagram shows how exceedingly fast the diametric growth of the crystal must be in the first tenth of a second of its existence. Hence we have an explanation for the suddenness of its appearance to the eye of an observer, and for the blurred edges of its photographic image. It is true that another cause may contribute to the blurred effect; namely, the irregular refraction caused by the convection of the lighter solution which has just deposited part of its load; but the speedy growth alone is capable of explaining the observed indistinctness.

Interesting as the rapid initial growth in diameter may be, it places a serious bar in the way of more precise study of the birth of crystals. One clearly needs not only high magnifying power but also great speed; and these two together require very intense light. Whether or not we shall be able to obtain more positive knowledge with the present apparatus is questionable. The same phenomenon casts a measure of doubt over some of the observations of Link and his followers. Is it not possible that the subjective effect of the rapidly growing crystal might be mistaken for that of a globule of liquid? Even upon the photographic plate there is a slight resemblance, and in one or two cases deliberate stuay is needed to detect evidence of structure in the smallest crystals.

In conclusion, the report of the foregoing pages may be summarized as follows: It has been found possible to take very frequent photomicrographs of crystals during their birth and growth. An enlargement of over 4,000 diameters was obtained, and both common and polarized light were used. Only substances with high melting-points were examined, and the crystallization was always from aqueous solution. No properly focused image on any of the plates seemed to be devoid of crystalline structure. The growth in diameter during the first second of the crystal's life was found to be vastly greater than during the subsequent period. Not the diameter itself, but a power of the diameter, was proportional to the time under the conditions used in our experiments. This exceedingly rapid initial diametric growth accounts for a lack of definition noticed in the first images—a lack of definition sufficient to have misled the eye, but not enough wholly to obscure the photographic evidence of crystalline structure.

Hence we may conclude that whatever theoretical reason there may be for believing that crystals always develop from a transitory liquid phase, the present experimental evidence is inadequate to prove that these globules attain a size visible in the microscope, except in the case of substances which melt at temperatures not far from the temperature of crystallization. The present paper is to be regarded rather as the suggestion of a mode of study than as a finished treatment of the subject, however.

The apparatus might be used to obtain a series of kinetoscopic pictures of insects or other small animals or plants, and is now being used for the study of the change in structure of steel at high temperatures. We are indebted to the Rumford Fund of the American Academy of Arts and Sciences for much of the apparatus used in this work.

Chemical Laboratory of Harvard College, Cambridge, Mass., October, 1898, to October, 1900.

ON THE RADIO-ACTIVITY OF MATTER.*

By Henri Becquerel, D.C.L., Ph.D., Member of the Academy of Sciences, Paris.

The property possessed by certain bodies of emitting invisible and penetrating rays was unknown six years ago. The speculations brought about by the experiments of M. Roentgen led to the examination of material bodies, to see if any of them had the power of emitting similar radiations; the phenomenon of phosphorescence naturally was first thought of, being a known method for the transformation and emission of energy. This idea, however, could not be applied to the phenomena with which we are occupied, but it was very fruitful. It led to the choice, among phosphorescent bodies, of the salts of uranium, of which the optical constitution is remarkable on account of the harmonic series of the bands of their absorption and phosphorescent spectra. It was while experimenting with these bodies in 1896 that I first observed the new phenomena which I am about to bring before you this evening. I have here the plates of the double sulphate of uranium and potassium, obtained by Lipmann's method, which I used for my first experiments.

After having placed one of these plates on the black paper which covered a photographic plate, and leaving it for several hours, I observed on developing the plate that the uranium salt had emitted certain active rays, traversing the black paper, as well as various screens interposed between the plate and the active body, such as thin sheets of glass, aluminium, copper, etc. I soon saw that this phenomenon had nothing to do with phosphorescence, or with any known method of excitation, such as luminous or electric rays, or any appreciable variation of temperature.

I had to deal, therefore, with a spontaneous phenomenon of a new order. The absence of any known exciting cause on a body prepared in the laboratory several years ago, caused me to think that the phenomenon would have been the same at any time it might have been observed; it should therefore be permanent, that is to say, there should not be any appreciable weakening after a very long time. This is, in fact, what I have proved during the past six years. I will show you the first proof I had of the spontaneity of the rays; these rays have traversed the black paper which covered the photographic plate, and a thin strip of copper in the form of a cross. Here again is the radiograph, made about the same time, of an aluminium medal; the unequal absorption of the different thicknesses has caused the appearance of the effigy thereon. After the very first observation I observed that the new radiations would discharge electrified bodies, at some distance in the air, a phenomenon which gives us a second method for studying these rays; the photographic method is specially qualitative, while the electrometer furnishes numerical elements of comparison.

In the course of these first observations, I was led away from the path toward which later experiments brought me back by several facts, of which the following is the principal: Having protected a photographic plate by means of a sheet of aluminium 2 mm. in thickness, and having arranged on the aluminium several samples of phosphorescent powders, placed on separate plates of glass, and covered with small tubes like clock shades, the photographic proofs, obtained after forty-eight hours, showed silhouettes of the plates of glass just as if they had been produced by the total refraction and reflection of rays identical with those of light, but which must have traversed the 2 mm. of aluminium. This photograph is unique; I have never been able to reproduce it or obtain any action with the same sample of sulphide of calcium, nor with any other phosphorescent preparation. At about the same time M. Niewenglowski obtained an impression with sulphide of calcium, and M. Troost with hexagonal blende. To this day I do not know the cause of the activity of these products or its disappearance. These facts, and some others, gave me the idea that the new rays might be a transversal movement of the ether analogous to that of light; but the absence of refraction and a large number of other experiments made me abandon this hypothesis.

In this same year, 1896, I found that all the uranium salts emitted rays of a similar nature, that the radiant property is an atomic one belonging to the element uranium, and electric measurements showed me that metallic uranium was about three and a half times more active in ionizing air than is the double sulphate of uranium and potassium. The same method enables us to study the rôle played by the gases in the discharge, and to observe that a sphere of electrified uranium retains its charge *in vacuo*, while in air it loses it. The rate of the fall of potential is sensibly proportional to the potential if the latter is only a few volts; it should be constant and independent of the potential when this is very high. Gas rendered conducting by these rays retains this property for some instants. Between two conductors maintained at constant potentials these rays set up in air a continuous current.

These experiments were taken up and elaborated by Lord Kelvin in 1897, then by Messrs. Beattie and S. de Smolan. In 1899 Mr. Rutherford showed how the phenomena due to the conductivity communicated to gases by uranium, and the existence of a maximum in the current produced, could be explained by the hypothesis of ionization, to which the beautiful work of Mr. J. J. Thomson has given the seal of authority.

In 1898 M. Schmidt and Mme. Curie observed, quite independently, that thorium has properties analogous to those of uranium, properties which were specially examined by Mr. Owens and Mr. Rutherford. Mme. Curie having measured the ionizing activity of a large number of minerals containing uranium or thorium, announced the remarkable fact that several minerals were more active than metallic uranium. M. and Mme. Curie concluded that there must be a more active body than uranium in the minerals, and they undertook the task of isolating it.

By treating one of the most active of these minerals, viz., pitchblende from Joachimsthal, they first separated an active bismuth, to which they gave the name

* A Discourse delivered before the Members of the Royal Institution, Friday, March 7, 1902.

of polonium, then shortly afterward they obtained a very active barium containing a new element, radium. These bodies are prepared by fractional precipitations, in which one is guided by the indications of the electrometer; the activity of these products is 100,000 times greater than that of uranium.

About the same time M. Giesel succeeded in preparing some very active substances, and in 1900 M. Debierne announced the existence of a new element, actinium, about which, however, we have not heard many particulars. Of all these new bodies radium alone is characterized as a new element; it has an emission spectrum consisting of lines which do not belong to any other known body, and the atomic weight of the active salts of barium was found to increase with the proportion of radium present.

The activity of uranium was not sufficient to excite phosphorescence in other bodies; M. and Mme. Curie, however, observed this phenomenon with the rays from radium, and further, that the salts of radium were themselves luminous, their luminosity being, like their radio-activity, spontaneous. The activity of radium produces various chemical reactions; it colors glass, it transforms oxygen into ozone, it changes white phosphorus to red, it ionizes not only gases but also liquids, such as petroleum and liquid air, and insulating solid bodies, such as paraffin, developing in this latter body a residual conductivity which lasts a long time after the rays have ceased to act. It also causes on organic tissues serious burns analogous to those produced by X rays.

The sample of radium that M. and Mme. Curie have lent me for the purpose of this lecture enables me to show you a few of these phenomena—ionization of the air, luminosity, and phosphorescence.

I have observed by means of the photograph I now show, that the radio-activity of polonium will not traverse a thin sheet of black paper forming a small cylinder closed by aluminium or mica, and at the bottom of which was placed the powdered material; the rays from radium easily pass through this envelope; we shall see that still more profound differences exist between these two kinds of rays.

The radio-activity of radium restores to certain crystals, and to glass, the property of becoming phosphorescent by heat, which they have lost owing to a previous elevation of temperature.

The phenomena of absorption, examined either by means of photography, by phosphorescence, or by ionization of the air, showed the heterogeneity of the class of radiations emitted; subsequent observations have enlarged the field of this research.

Toward the end of the year 1899 M. Giesel, and then MM. Meyer and Schweidler, observed that the rays of radio-active preparations were deviated by a magnetic field in the same manner as are the cathodic rays. For my part, at about the same time, without having heard of these experiments, I observed the same phenomenon with radium. The experiment can be made in the following manner: A small paper cylinder containing a few grains of the radio-active body is placed horizontally on a photographic plate covered with black paper, between the poles of a magnet; the rays are thrown entirely to one side of the plate. I here show my two first photographs, one of which shows a concentration on one pole of the magnet.

Very shortly afterward I observed that the rays from polonium are not deviated, and consequently that two kinds of rays exist, one deviable and the other non-deviable. M. and Mme. Curie have made an electric examination of this subject which has proved the simultaneous existence of these two kinds of rays in the radio-activity of radium, their unequal permeability varying with the distance from the absorbing screens. The accompanying photograph shows these two kinds of rays from radium; I have recently observed that uranium emits only deviable rays, that is, saving the existence of much less active, non-deviable rays. In fact, there does exist a third kind of rays which are not deviable, but are extremely penetrating; they have been shown more particularly by M. Villard.

Thus the activity of radio-active bodies comprises three kinds of rays—rays which are deviable in a magnetic field, which appear to be identical with cathodic rays, and two sorts of non-deviable rays, one kind being very easily absorbed, the other resembling X-rays and being very penetrating. Uranium emits principally the first kind, polonium gives only the second, and radium gives all three at once.

Let us now return to deviable rays; the material theory of Sir William Crookes and Mr. J. J. Thomson can be applied to them, and the consequences can be verified with the greatest facility. In a uniform magnetic field the trajectories perpendicular to the field are circumferential to the path ρ which leads the rays to the point of emission. For an oblique emission making an angle with the field, the trajectories are helices enveloping the cylinders with rays $\rho \sin a$. By placing on a horizontal photographic plate parallel to the uniform field, a small lead box containing a few grains of radiferous barium forming a source of very small diameter, the rays are drawn down to the plate, and excite it on one side alone; a bundle of simple rays emitted in the plane normal to the plate and parallel to the field should show theoretically an arc of an ellipse of which the axes are in the proportion of 2 and π. The accompanying photograph shows these theoretical arcs, obtained by reversing the direction of the field, the one in air and the other *in vacuo*, on a photographic plate enveloped in black paper; the intensity of the magnetic field was about 4,000 C. G. S. units.

If we do not inclose the photographic plate, and if we arrange on it several strips of paper or of metal to form screens, we observe in the print of the radio-activity dispersed by the magnetic field, a species of absorption spectra. Each trajectory has a different curvature corresponding to rays of different speeds and having different penetrating powers.

Here is an example of one of these prints, obtained in a field of about 1,740 C. G. S. units; the screens are a strip of black paper, a strip of aluminium of 0.1 mm. thickness and a strip of platinum of 0.03 mm. thickness. To obtain a pure spectrum so that at each point of the plate a bundle of rays are found, of which the trajectories have all the same curvature, the rays should be made to issue from the source so as to pass through a small round opening; the result is the same as the preceding one. This latter also shows a very intense impression, due to the secondary rays, provoked by the rays which were stopped by the lead cover over the active body, and in which was made a small opening through which the pure spectrum passed. The absorption varies with the distance of the screen from the active body, and the rays which are stopped by a screen placed on the plate are able to traverse this same screen when it is interposed at a point near their source.

These experiments leave little doubt as to the identity of the deviable rays with cathodic rays. However, it was necessary to prove that they carry charges of negative electricity, and that they are deviated by an electric field.

M. and Mme. Curie, in a beautiful experiment, have shown that the rays of radium charge negatively the bodies that receive them, and that the source becomes charged positively. For this double experiment it is necessary that all the conductors and the source itself be completely enveloped in an insulating material, such as paraffin. For the active body examined the charge was 4.10^{-13} C. G. S. units per square centimeter of radiating surface per second.

For my part, I have shown and measured the electrostatic deviation by projecting the deviated shadow of a screen placed perpendicular to the field, on a photographic plate. One of these apparatus is here shown, as well as one of the prints obtained, in which on the two halves of the same plate appear the two deviated shadows corresponding to the reversal of the electric field, of which the intensity was $1.02 : 10^{12}$.

The ballistic hypothesis attributes these phenomena to material masses transporting charges of negative electricity with very great rapidity. Let m be the material mass of a particle, e its charge, and v its velocity. We know that in a magnetic field of an intensity, H, the radius of curvature ρ of the circular trajectory is given by the equation $H\rho = \frac{m}{e} v$. The numerical value of the product $H\rho$ serves to show the character of each simple ray. On the other hand, in an electric field of an intensity, F, the parameter of the parabolic trajectory is $\frac{m}{e}\frac{v^2}{F}$. The knowledge of these two values gives $\frac{m}{e}$ and v. With a value of $H\rho = 1{,}600$ I obtained approximately $v = 1.6 : 10^{10}$, and $\frac{e}{m} = 10^7$. These figures are entirely of the same order in value as those which led to the measurements made with cathodic rays, and the theoretical considerations with regard to Zeeman's experiment.

From the above figures we deduce that, from the fact of the deviable radio-activity under consideration, there escapes from each square centimeter of radio-active surface 1.2 mgrms. of matter in a thousand million years.

By extending these measurements to radiations of different and well-known natures, we ought to be able to determine if the relation $\frac{e}{m}$ is constant, or variable with one ray or another, and whether these do not differ only in their speeds; I have not yet finished the experiments I undertook to decide this fundamental question, but recently M. Kaufmann has attempted to elucidate the matter. He combined, at right angles, the magnetic and the electric actions; unfortunately, the experiment, which is very difficult to perform, did not give him one plate fit to measure. For the values of $H\rho$ comprised between 1,800 and 4,600, he found that the relation $\frac{e}{m}$ varied from $1.3 : 10^7$, to $0.6 : 10^7$, and the speed v from $2.3 : 10^{10}$ to $2.8 : 10^{10}$.

The proof of a regular variation in the calculated relation $\frac{e}{m}$ is of considerable theoretical importance; if this relation was constant, as it seemed to be as the result of a large number of measurements, we might conclude that the slightly deviable rays, for which $H\rho$ is more than 5,000, have speeds considerably greater than that of light.

On the other hand, theoretical considerations have given the idea that the speed could not surpass that of the propagation of electro-magnetic disturbances, that is to say, the speed of light, and we have been led to consider the mobile masses in a magnetic field as endowed with a particular inertia which is a function of the speed. Under these conditions the calculated mass ought to be apparent, or at least partly so, and it should increase indefinitely as the actual speed approaches that of light. The figures published by M. Kaufmann bear out this hypothesis.

Another consequence of this manner of looking at the question would be that there should be continuity between the deviable rays and those which are not, as the radius of curvature of the trajectories becomes infinite at the same time as the apparent mass.

The photographic print already mentioned, as well as one of the following ones, showed, on the contrary, a very distinct discontinuity, although in the second one the exposure was sufficiently prolonged for the impression of the least active rays, such as the penetrating non-deviable ones, to be distinctly visible.

This proof was obtained in the following manner: In the uniform magnetic field of a permanent magnet I placed, normally to the field, a photographic plate, then on this latter I arranged screens of lead fixed on a sheet of glass. These screens are pierced with openings normal to the plate, and destined to limit the width of the beam; in the path of these beams I arranged other screens, such as aluminium ones. Below the plate opposite a narrow slit in a strip of lead a small block of lead is placed having a deep cavity normal to the plate, and in which the radiant body is placed. We have thus a narrow, linear source normal to the plate and several millimeters in length. The cavity is covered with a thin sheet of aluminium to stop the light rays.

The figure represents a section made normally to the field of the beam, of which a part is deviated. Each beam corresponding to a determined speed gives an impression which is noticeably curved, as if the entire trajectory was marked on the plate. In these photographs the interior of the cylinders forming the screens is strongly affected by the secondary emission from the lead. The first picture shows that through each opening there passes an infinity of rays, constituting portions of the pure spectra. These meet with a strip of aluminium 0.1 mm. in thickness, and traverse it without deviation, but not all with equal facility. The slightly deviated rays are penetrating, and excite secondary radiations when leaving the aluminium. The very deviable rays are stopped and give rise to points affected by an intense secondary radiation.

One only of the two categories of non-deviable rays appears in the form of two fine lines opposite the source; these are very penetrating rays, the others were arrested quite near the source.

Another picture shows the simple beam obtained by a double series of openings; by one of them we can sometimes pass two distinct trajectories.

The third figure is of interest, as it shows the straight beam traversing, without deviation, a sheet of aluminium placed obliquely to the line of trajectory; and, finally, the fourth one shows the transmission of simple rays through aluminium, and the secondary effects they produce.

The same method has enabled me to observe that the secondary rays were themselves deviated by the magnetic field, in the same way as the exciting rays.

The radiations from radium also comprise some which are very penetrating, consisting of the least deviable and the non-deviable rays, of which the properties seem to be the same as Roentgen rays. These penetrating rays are but very slightly absorbed, and consequently their action on a photographic plate or on the air is very feeble, so that, by the preceding methods, we can get no very exact idea of their intensity. If we interpose in their path a very absorbent screen, they traverse it partially, but at the same time they become partially transformed into more absorbable rays. This transformation recalls that of fluorescence, and, through the secondary action, the effect immediately behind the screen is stronger than if this latter was not there. The photographic plate receiving the radiations—filtered through a thickness of lead of 1 cm.—gives a stronger impression through a sheet of lead of 1 mm. thickness than in the uncovered regions. The diagram shows the effect of the radiations coming from the sides of a leaden box after having traversed 5 to 12 mm. of the metal.

These secondary phenomena may partially account for the appearance of shadows given by the edges of all the transparent screens placed over the photographic plates.

All the facts I have just related have exclusively to do with the obscure radiations which traverse opaque bodies, such as metal, glass, mica, etc. But there exists also another, quite different, phenomenon, of which the effects are arrested by glass and mica; they are comparable to those produced by a vapor of a special nature. This phenomenon was discovered in 1899 by Mr. Rutherford and by M. and Mme. Curie simultaneously.

Mr. Rutherford, while examining the radiations from thorium, observed that, besides the ordinary rays, there was another effect produced by an "emanation" consisting of a sort of vapor ionizing the air. This vapor is deposited on bodies, principally those electrified negatively, and makes them momentarily radio-active. Mr. Rutherford made some very interesting measurements of this phenomenon.

At the same time, M. and Mme. Curie discovered that, under the influence of radium, bodies became temporarily radio-active. This is not the secondary effect already described, but a persistent phenomenon which disappears comparatively slowly from the moment when the action of the radium ceases. M. Curie has called this "induced radio-activity," and has made a very complete examination of it. He has observed that the phenomenon is produced with great intensity in a close space, that induced activity is the same on all bodies and practically independent of the pressure inside the inclosed space, but that the phenomenon is not produced if we maintain a complete vacuum by removing the gases produced; solutions of salts of radium produce the same effect with greater intensity than the solid salts. Liquids, water of crystallization extracted from active salts, or the water separated from an active solution by a semi-permeable membrane of celluloid, remain strongly radio-active; it is the same with the gases. These excited bodies produce the same effects as radium; they emit a penetrating ray which traverses the glass vessels which contain them and makes these latter luminous. Induced activity is gradually propagated in gases in a sealed tube, even through capillary tubes and imperceptible cracks; bodies are excited the more as the volume of gas is greater in proportion to their surface. Phosphorescent bodies become luminous when excited. In a recent work, MM. Elster and Geitel have observed that atmospheric air has properties analogous to those of excited gases, and they have been able to collect on wires, negatively electrified, traces of radio-active products. The cause of this radio-activity is a problem of the greatest interest.

Finally, there is a remarkable method of induction, which is of such a nature as to demand the greatest reserve in the conclusions which might be formulated relative to the presence of new elements in radio-active bodies. Every inactive substance which has been added to a solution of a uranium or radium salt, and which has subsequently been removed by precipitation, has become radio-active, and loses this radio-activity very slowly. This fact was first observed by M. Curie and M. Giesel, who rendered bismuth radio-active in this manner. In the case of uranium, a trace of barium, precipitated in the form of sulphate, became notably more active than the uranium; barium thus excited emits only deviable rays, like uranium.

After this precipitation the uranium salt, brought back to the solid state, is less radio-active than before; this loss of radio-activity can even be accentuated by successive operations, but the products gradually and spontaneously regain their original activity. The tem-

porary diminution of activity after solution is a general fact for salts of uranium and radium. With salts of actinium M. Debierne has communicated a very great activity to barium. The barium thus excited can be separated from inactive barium; it can be fractioned like radiferous chloride of barium, the most active portions being the least soluble in water and hydrochloric acid. M. Debierne in this manner obtained a product a thousand times more active than uranium. Barium thus excited behaves as a false radium, but it differs from the true radium in the absence of the spectrum and in gradually losing its power with time.

Among the radio-active preparations a large number may be temporarily excited bodies. Such is the case with "polonium," which is apparently only excited bismuth.

Uranium and radium are characterized by their emission spectra and by the stability of their radio-activity. The spontaneous activity observed in the case of different salts after solution might find an explanation in a phenomenon of auto-induction of the active molecules on the inactive one they are associated with.

The origin of the radiant energy of these radio-active bodies is still an enigma. By the material hypothesis it does not appear unreasonable, by applying the phenomenon of the evaporation of an odoriferous body, to compare the emanation to a sort of gas, of which the molecules would have masses of the same order of size as electrolytic ions, and to identify the radiations with the cathodic rays resulting from the dislocation of these ions, and causing at the same time the emission of X-rays. We might thus ascribe the expenditure of energy to the dissipation of active matter. Although this hypothesis will account for most of the known facts, still there does not exist any precise experiment which sanctions it.

I must not, however, dwell longer on this subject, of which I have incompletely summarized the present position, by emphasizing the physical part, which comes more especially within my province, although the chemical side has given rise to work of the greatest interest.

These questions have raised new hopes on the transformation of matter. Besides the exceptional conditions under which they enable us to examine the cathodic rays, they have raised, and continue to raise, fresh problems every day of which the first and most mysterious is the spontaneity of the radiations.

NEW FRENCH DREDGES.

NOT very many years ago, the most powerful dredges had the aspect merely of heavy boats with ill-shaped hull just capable of moving of themselves to the right or left through the setting in action of their windlass around which anchorage cables were wound. At the same time, the means by which they brought up material from the bottom of the water was always a chain and buckets.

Doubtless we should not be ungrateful, and undervalue the services rendered by such dredges, which are still currently employed under many circumstances; but we must nevertheless take into consideration the fact that the dredge had to undergo a complete revolution in order to answer the new requirements which it was called upon to satisfy. It was necessary that it should work more quickly, and that it should be capable of effectively removing the essentially movable sand that is met with in so many estuaries of rivers and that the buckets laboriously collect in small quantities. The dredging had to be done at greater depths, since modern navigation requires such depths; and finally, in order to permit the dredge to operate in quarters most exposed to bad weather and in which it would be impossible for scows to come up alongside or it in order to take aboard the sand that it brings to the surface, it was of prime importance for the dredge to be self-moving. In a word, it must become a genuine boat, riding well on the sea, as well as a carrier capable of receiving the dredged mud and sand through its sides and of carrying it to a place of deposit where it would not prove an incumbrance. Moreover, in order to render it possible for it to operate at a great depth amid banks of sand, it became necessary to replace the buckets by a suction pipe which is lowered to the bottom of the water, and through which the sand in contact with the extremity of the pipe is sucked up by means of a pump.

The dredge, or rather the dredges that we purpose calling attention to, unite in themselves all these desiderata and all these improvements, since they are carriers of very great power, provided with suction apparatus and capable of developing a speed which, but a few years ago, would have satisfied a merchant vessel. They bear the names of "Seine II." and "Seine III." and were constructed by the Satre establishment, of Lyons, which makes a specialty of all kinds of dredging apparatus. They are designed to improve the estuary and channels of the Lower Seine between Rouen and Havre.

Similarly to commercial vessels, these two dredges, which are exactly alike, are provided with two screws. Their speed when loaded was on their trial trip 8½ knots.

Moreover, the boats reached the mouth of the Rhone, going under their own power by sea and through the Strait of Gibraltar, and they behaved splendidly in the rough weather which they encountered. It must be said that their hull is constructed in such a way as to satisfy all the requirements of the Bureau Veritas. The screws are provided with four blades and may be controlled, through a rapid gear, by means of the engines, which actuate also the suction and dredge pumps.

The new Satre dredges are of very large dimensions for boats of this kind. They are 195 feet in length, 34.5 feet beam, and 14.45 in depth. The hull is divided into ten tight compartments by eight bulkheads, which would allow the boat to float even after a serious accident to one of the compartments. Two vertical compound engines of the most improved type are used. They are capable, both together, of developing 540 indicated horse power at 150 revolutions per minute. The pistons are respectively 17.6 and 35.2 inches in diameter, and have a common stroke of 18 inches. The engines are supplied by two Belleville boilers. The capacity of the fresh water reservoir is such as to permit of an uninterrupted run of 75 hours.

The dredging apparatus is very simple, since it consists essentially of a suction pipe placed upon the side of the boat so that it can be let down till it touches bottom at a depth of 42 feet. Through its upper part, which is provided with a flexible coupling and a gimbal joint, and a horizontal pipe arranged upon the deck, it is connected with two centrifugal pumps, each actuated by one of the engines. Owing to the flexible coupling just mentioned, the dredging operations may be prosecuted even in a gale of 1.5 feet a minute. The pumps suck up 17.625 cubic feet of sand in 38 minutes with a consumption of but two pounds of coal.

The material sucked up is forced into chutes that extend along foot bridges crossing the seven wells that open into the compartments on each side. These chutes are provided with gates that open into the wells and control the filling of the various compartments. Each compartment, of course, is provided with a dumping gate which is operated by a special windlass installed upon the deck in the rear of the large hopper. The windlass just mentioned is actuated by the steam produced in an auxiliary multitubular boiler, which furnishes steam also to other windlasses, either for weighing anchor or for towing in a heavy sea. It assumes also the electric lighting and the heating of the vessel. By the light of 1,000 candle power arc lamps arranged upon the deck, work may be carried on at night as well as in the daytime.

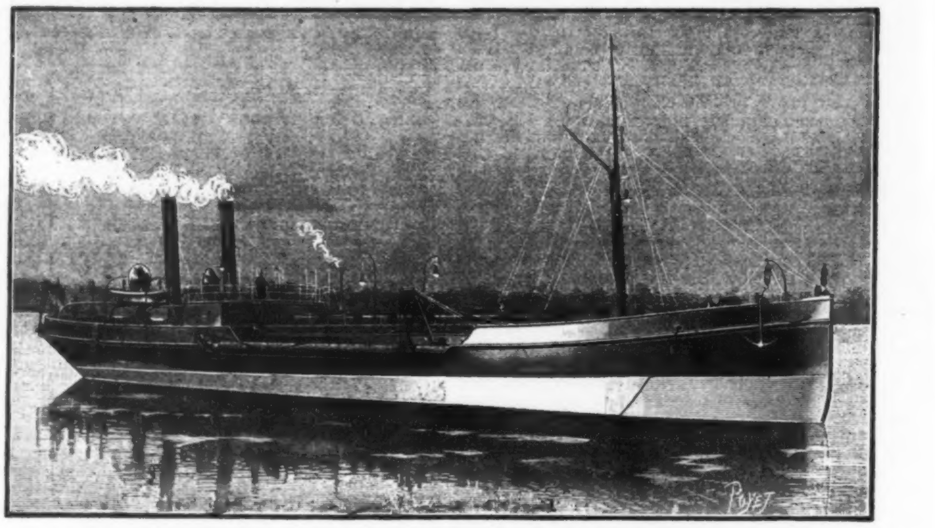


FIG. 1.—ONE OF THE NEW DREDGES OF THE LOWER SEINE.

Special quarters are arranged in part for the crew, and cabins in the rear for the officers.

From what has been said, it will be seen that these new dredges combine all the most modern improvements.—La Nature.

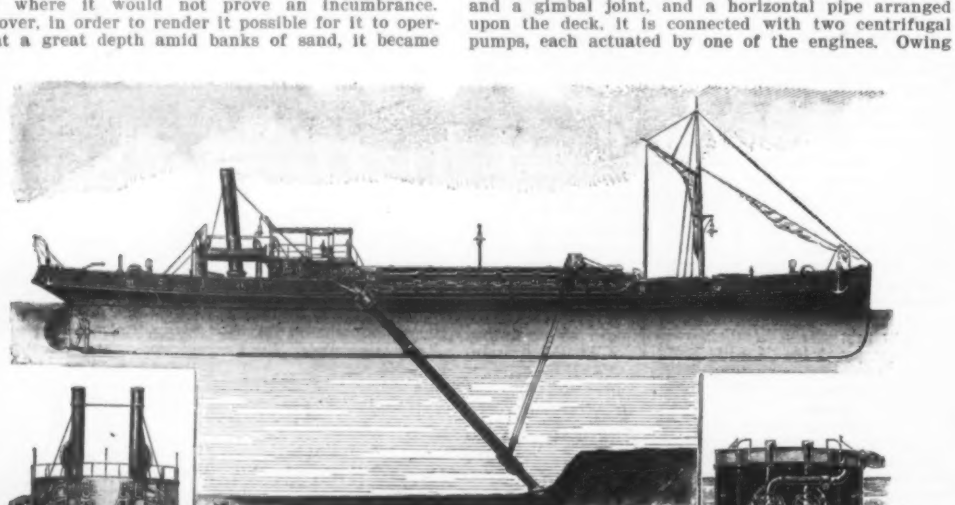


FIG. 2.—THE DREDGE IN OPERATION.

A BALLOON TRIP OVER THE ALPS.

VERY elaborate preparations are being made in France and Switzerland to cross the Alps by balloon. The idea is by no means new, and it is quite unnecessary to show how enticing is this thought of being carried without trouble over those heights and snow fields. Archduke Leopold Salvator, Field-Marshal-Lieutenant and Commander of the Twenty-fifth Infantry troop division in Vienna, who a year ago acquired the balloon "Meteor" from the well-known Augsburg balloon maker, August Riedinger, resolved only this spring to undertake an air trip from Salzburg. At this place the conditions were especially favorable, in that Salzburg, with its mountainous surroundings in three directions permits very satisfactory balloon excursions to the north, east and south. Even the only open direction, toward the west (Bavaria), offers an interesting, picturesque and highly cultivated tract of land.

The excursion planned for April the first had to be postponed, as Jupiter Pluvius held sway in Salzburg. However, about the middle of April, fine weather was expected for that magnificent region. On the evening of the 15th the Archduke, accompanied by Capt. Hinterstoisser, Commander of the Imperial and Royal Aeronautic Department, left Vienna, reached Salzburg at 3 o'clock the next morning, and had the balloon "Meteor," which they had brought as luggage, inflated at the gas works. This was the work only of an hour and a half, and the departure should have taken place at 5:30, but heavy clouds hung low down, and it almost appeared as if once again the trip would be prevented through unfavorable weather. About 7 o'clock, nevertheless, the Archduke decided to make the ascent in spite of the cloudy sky. He entered the basket with Capt. Hinterstoisser, and upon the stroke of 7 the "Meteor," with almost 200 kilogrammes of ballast, soared out of sight of the numerous curious spectators. At a relative height of 300 meters the balloon dived into the clouds and remained in them until a height of 1,200 meters was attained. In order to pass through this cloud layer, five bags (100 kilogrammes) of sand had to be sacrificed. At last at 8 o'clock the balloon had clear sky overhead, and, at a height of 1,500 meters, sailed in most glorious sunshine over the vast cloud sea, out of which only those peaks exceeding 1,200 meters in height projected like so many islands. As the balloon ascended higher, the view broadened. and at 10 o'clock the aeronauts, suspended over the Tännengebirge at a height of 3,000 meters, enjoyed the most magnificent Alpine panorama: snowfields under the balloon, close at hand the Hochkönig, the Steinerne Meer and the Watzmann, farther in the distance the chain of the Hohe Tauern with the Grossglockner and the Dreiherrn peaks. The desolate, lifeless mountain giants, the vast snowfields and the solitude high over the cloud sea, made the heart quake and tremble. When the balloon at 10:30 A. M. had reached its maximum height of 4,200 meters over the Dachstein peak, the aeronauts obtained a quite indescribable view of the snowclad mountains lying far below, where never a trace of man or living creature was visible. Only that, out of the thick clouds, the piercing whistle of a locomotive recalled to mind that there, far below, life

had not ceased and the ever-hurrying world still raged on.

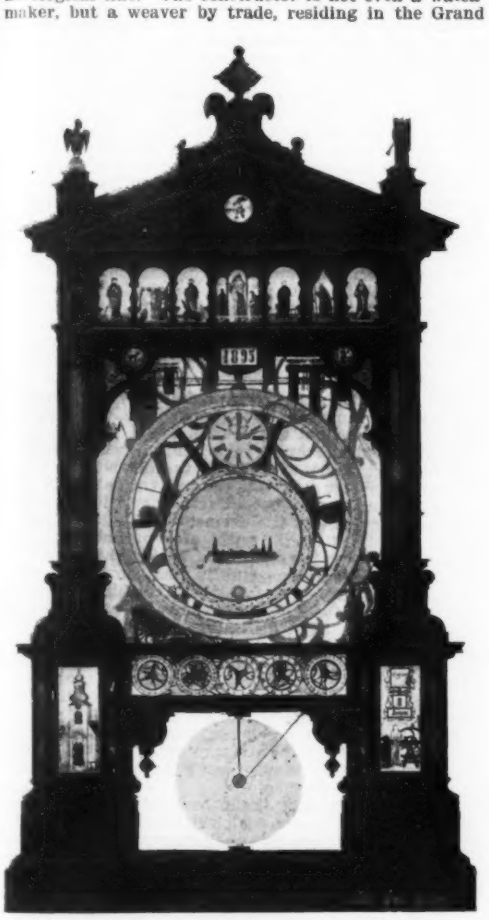
A powerful pull on the valve, and down went the balloon. Heavy, condensed clouds soon enveloped and carried it downward. Good-bye for to-day, radiant sun! The descent was uninterrupted; in scarcely fifteen minutes the balloon was below the clouds. Where did the aeronauts find themselves? Surrounded by high pinnacles, unhospitable woods and narrow valleys. The aeronauts' luck, however, ushered the "Meteor" right into busy life. The landing was effected without difficulty at Weisskirchen, not far from Judenburg (Styria). The worthy country folk did everything but welcome the guests fallen from heaven, or rather from the clouds. They had never before seen a balloon, and ran away from it. Soon, however, they persuaded themselves that the arrivals were really men. The balloon was quickly packed, and toward evening the participants in this wonderful, never-to-be-forgotten trip arrived in Vienna.

The inferences drawn from this Alpine trip are briefly as follows: 1. That to cross the Alps in a balloon is an undertaking not absolutely free from danger. 2. That one must take this air trip only in summer, never in winter or spring. And 3. That an excursion over the Alps guarantees the enjoyment of magnificent and wonderful nature.

The balloon, which had commenced the ascent at 7 in the morning, landed at 11 A. M.; it had thus made the distance of 179 kilometers in four hours. The lowest temperature amounted to 9 deg. Centigrade.—Translated from Illustrirte Zeitung.

A MARVELOUS CLOCK.

We herewith present to our readers an illustration of the Spaeth astronomical calendar clock, as well as a photograph of the movement. This wonderful clock is said to surpass everything known heretofore in the horological line. The constructor is not even a watchmaker, but a weaver by trade, residing in the Grand



THE ASTRONOMICAL CALENDAR CLOCK.

Duchy of Baden, Germany. It was his aim to excel in his work even the famous clock at the Strasburg Cathedral, which he had seen, and Dr. F. Bistenpart, of the Berlin Academy of Sciences, certifies to the fact that he has fully succeeded in this. The clock was commenced twenty-four years ago, and represents no less than nineteen years' continual labor. The ingenious achievement cost Spaeth no end of trouble, and the history of his vicissitudes is a most interesting one. He was summoned before the magistrate on complaint of his wife, and was for a time put in a lunatic asylum, but finally managed to get out again, and bravely stuck to his work in spite of everybody. He was severely handicapped by the lack of funds, and completely ruined himself, selling all his belongings to attain his goal. He was at one time financially assisted by Emperor William I., who was much interested in his work.

The movement consists of 2,200 parts, 142 of which are wheels. Each part is in itself a work of art, all the wheels being sawed out in fancy designs instead of the usual legs, also the plates, levers, bridges, everything is executed by hand in fine scroll-work, polished and gilt, or nickeled.

The case, in Renaissance style, is 215 centimeters high (with the base 265 centimeters), 105 centimeters long and 54 centimeters wide. The whole clock weighs a little more than 300 pounds. The case is constructed in such a manner that every function can be seen through glass panes.

The clock shows the seconds, minutes, hours, dates, the days of the week (by picture as well as letters), months, seasons of the year, number of the year, pictures of the signs of the zodiac, the rising, setting, and exact position of the sun, moon, and stars of our zone; also the phases of the moon, and all the eclipses of the sun and moon. It contains the complete perpetual calendar with its accurate statements, the astronomical practica, and adjusts automatically at the beginning of each year, the statements of the astronomical practitioners in explanation of the everlasting calendar, as well as Easter and the movable festival days of each year in a faultless manner.

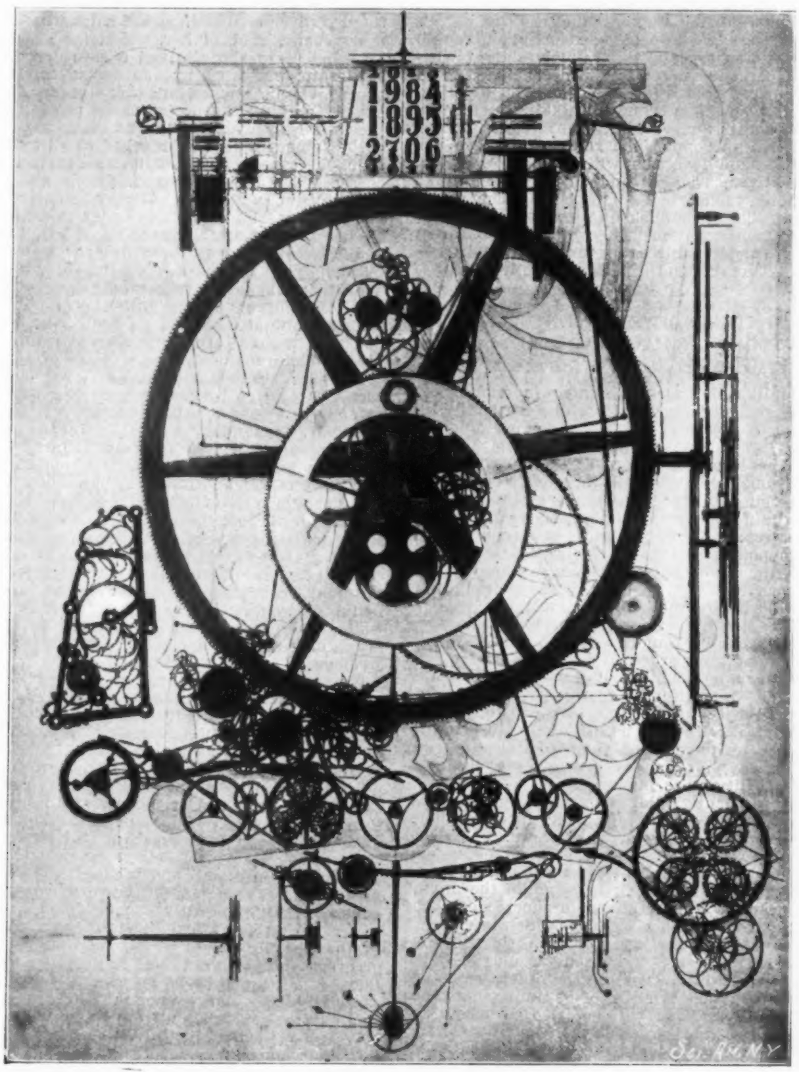
A glass ball representing the spherical globe shows the exact movements and positions of the planets: Mercury, Venus, earth and moon, Mars, Jupiter, Saturn and Uranus.

Besides, the work is embellished with more than a hundred mostly so-called living pictures.

Every quarter of an hour the image of the Guardian Angel appears in the principal field on the left. The striking of the quarters is done by two angels standing in the second recess on the left side, while in the sixth recess two figures at a time, representing the four ages of man, are changing alternately. On the right side of the principal field the Angel of Death advances, pointing with his scythe to the dial plate.

When the full hour strikes, the center angel of the second recess appears holding an hour glass, while the angel on the right side above is sounding a trumpet.

Under the roof an allegorical figure represents symbolically the respective seasons of the year, while above



THE MOVEMENT OF THE CLOCK.

the principal year the guiding star of the year appears.

On the left of the clock cabinet stands a rooster which five minutes before noon flaps its wings, stoops its neck, opens its bill and crows three times. After the clock has struck twelve at noon he crows again, and when the picture of the season shows Spring, there appears a cuckoo above. Summer is represented by a quail, which issues forth on the left side, both birds calling seven times. A bull, lying at the feet of St. Luke the Evangelist, roars to symbolize Autumn, and when Winter is indicated, a lion, lying close to St. Mark, roars.

Every time the clock strikes twelve, the twelve Apostles appear in the center field, bending their heads before the image of Christ, and a monk standing in the portal above rings his "Ave."

Furthermore, the clock contains a small but melodious chime which plays for five minutes after the striking of an even hour, the melodies changing automatically, and each lasting one minute. The work has twelve little bells and on the roller are 997 pins, which make the music.

The builder of the clock has written three books containing very explicit explanations, as well as drawings and the most exhaustive directions for the taking apart and correct putting together (for hundreds of years ahead, of course), so that any capable clockmaker can do any oiling, etc., that may become necessary. In this manner the work is preserved to the posthumous world. The books give particulars regarding the five years' study of the constructor on mathematics and astronomy, revealing a most phenomenal mathematical knowledge.

PHOTOGRAPHIC PLATES.

The operation of making photographic plates is one which most persons are content to leave to the specialists, as the work is somewhat troublesome. The pharmacist, however, who has sufficient leisure might find experiments in this line profitable. It is interesting, at all events, to know how the work is done.

The dry plate now so widely used consists of a sheet of glass coated on one side with a so-called emulsion, the base of which is gelatin, with which are incorporated the sensitive chemicals required.

Dr. Eder, in his work on emulsion photography, gives among other formulas the following simple one, which he says may be relied on even in unskilled hands.

Twenty-four grammes of potassium bromide and 40 grains of gelatin are dissolved by the aid of heat in 300 c.c. of water, and as soon as solution is complete, the temperature of the liquid is raised to 40 deg. or 45 deg. C. and a solution of 30 grammes of silver nitrate in 300 c.c. of water in introduced. The resulting emulsion is placed in a water bath at a low temperature; namely, 32 deg. to 35 deg. C. and digested at this temperature. If an emulsion as sensitive only as collodion is required, six hours digestion will suffice; for greater degrees of sensitiveness, digestion may be continued as long as three days.

As it is essential that the temperature should not rise above 35 deg. C. it would scarcely be practicable to conduct the longer operation without the aid of a gas oven regulated by a thermostat. For shorter periods one might apparently manage by the use of the following contrivance recommended by another writer; namely, a tin vessel of large capacity provided with a lid and entirely covered with a thick woolen "jacket," which is filled with water of the required temperature; in this is suspended the vessel containing the emulsion. The body of water will cool but slowly; it must of course be renewed from time to time.

After the digestion is finished the emulsion must be washed to remove all the water-soluble salts which remain in it.

When the emulsion has "set," which change is hastened, if necessary, by immersing the container in cold water, scrape it out of the bottle with a silver fork into a clean piece of muslin, taking care to break it up as much as possible into small shreds. Tie the muslin into a bag and suspend in enough clean distilled water to cover it. Allow it to remain in this water for several hours, then renew the water, rubbing the emulsion between the hands from time to time in order to facilitate the washing out of the salts from the emulsion with the least quantity of water. This operation of washing and squeezing must be continued until the water that drains from the emulsion

will not give a cloudy precipitate when tested with a solution of silver nitrate.

If the washed emulsion has increased much in bulk while in the muslin bag, squeeze it as much as possible and allow it to drain in the empty boiler for some hours, with an occasional squeeze. Alcohol may also be used to get rid of the extra water absorbed by the emulsion. By covering with alcohol, it soon decreases in bulk, and a couple of washes in water leave it in a condition to be melted and coated on the plates.

If, in coating the plates, the emulsion does not flow readily, the addition of 5 per cent of its volume of alcohol will overcome the trouble. In the case where alcohol has been used to reduce the volume of the washed emulsion, further addition of alcohol may not be necessary.

It is scarcely necessary to say that all the various steps of making the emulsion and coating the plates must be conducted in the dark room, and even the red light [illegible] as possible for fear that the work may be injuriously affected. Care must be taken to have all the vessels and implements employed scrupulously clean, which injunction, of course, applies also to the glass plates on which the emulsion is spread. To render them chemically clean it is recommended to immerse them first in nitric acid, then rub with a strong solution of caustic soda in alcohol and rinse in pure water.

It is necessary in carrying out any process for making the emulsion to use distilled water, as the ordinary article is liable to contain substances which interfere with the reactions which must be brought about. Gelatin is sometimes contaminated with sulphurous acid, which renders it unfit for photographic use.

Some years ago we copied from a photographic journal an emulsion process which involved the formation of silver carbonate; we afterward concluded from a consideration of disastrous explosions of indelible ink in which silver nitrate and an alkaline carbonate were present, that it would be best to avoid the process last referred to; the explosions referred to have not been explained, and it seems within possibility that formation of silver carbonate under certain conditions may lead to its explosive decomposition. The result aimed at can be accomplished without either carbonates or ammonia, as shown above; and it is safest to follow methods in which they are not required.—The Druggists Circular and Chemical Gazette.

RECENT SCIENTIFIC DEVELOPMENTS AND THE FUTURE OF NAVAL WARFARE[1].

By MR. WILLIAM LAIRD CLOWES.

AT a time like the present, which is one of extremely rapid scientific progress, it is especially incumbent upon us not to neglect, even for a single unnecessary day, any device which may possibly enable us, either in peace or in war, to defeat our rivals by honorable means. Scientific discovery tends ever more and more to obliterate the significance of those physical and moral differences which anciently rendered one race superior to another; and brain and thought are already more potent factors in the world than mere muscle and animal courage. Moreover, we know from experience that to-day or to-morrow may produce a complete revolution of method in almost any of our processes. We ought, therefore, never to sleep, save, as it were, with our ears and eyes open. Yet, strange to say, the amount of practical attention which we give to new machinery and appliances is often, I am afraid, inversely proportionate to the novelty and ingenuity of the device in question. We are too prone, when examining new inventions, to admire the cleverness displayed in them, and then to reject them, wholly and finally, for one of two reasons, both of which are in reality quite inadequate.

One reason frequently alleged is that the invention has yet to be brought to absolute perfection, and that, pending its complete evolution, we may safely neglect it. The other reason is that the machinery or apparatus is too delicate or complicated for use by the class of workmen who are accustomed to handle the appliances which the new apparatus would supersede. The evils resulting from such an attitude, which is characteristically a national one, are twofold. On the one hand, we snub and starve the inventor, and possibly drive him elsewhere in disgust; on the other, we make the far more dangerous mistake of assuming that the tide of technical education will not rise elsewhere so long as we choose to batten it down in our own little hold. What we ought to do is, surely, in the one case to take up promising inventions, and turning them over for development to the brightest intellects at our command, to enjoy the exclusive profits of them as soon as they shall be practically perfect; and, in the other, to educate our men up to the point of being able to use delicate and complicated appliances, instead of rejecting the appliances because our existing men are incapable of handling them. It is absurd for us to say, as in practice we do, "Don't offer us any unfamiliar novelty that isn't approximately perfected; and, above all, don't offer us any perfected novelty that isn't approximately familiar." While we continue to follow that policy we run the risk of falling out of station with the rest of the world, and of not discovering our error of position until too late.

It is mainly with the object of appealing for readier official interest in certain recent inventions, and for a greater official anxiety to educate the workman up to the level of the tools already available, or about to become available, to his hand, that I venture to address you on "Some Recent Scientific Developments and the Future of Naval Warfare." These developments must inevitably influence naval warfare strategically as well as tactically, and it is hard to say in which direction the effects are likely to be more important.

Within the compass of little more than a lifetime the practice of naval strategy has already been revolutionized by the introduction of steam and the electric telegraph. The principle of strategy, however, has suffered no change. It is very simple, and it may still, as in the days of Nelson, be thus formulated: To have at the right spot, and at the right moment, a fighting force superior in *personnel*, as well as in *matériel*, to the force of the enemy at the same time and place. But the practice is still changing rapidly, and, under the influence of recent invention, it must change still more. We have not yet realized to the full the strategical value of speed[2] as a factor in the successful carrying out of the fundamental object of strategy. Speed, in the present, is all that, and more than, the weather gage was in the past; and, if we neglect it, we shall cripple the hands of our admirals, no matter how many ships and men we may place at their disposal. It is the soul of all effective combination for offense; and I am not sure that it is not equally valuable as a means of defense against certain weapons which at present cannot easily be otherwise avoided—to-wit, submarines. The submarine, of which more anon, is essentially a slow craft, whether she travel on the surface or below it. A large ship can have no more secure protection against the submarine than the fact that she is in very rapid motion. A submarine must come to the surface to look about her; and if her big enemy be seen to be changing position rapidly, the submarine can gather little information that is likely to be of use to her.

And here I should like to say that our own preparations for attacking submarines with spar torpedoes[3], fitted to torpedo boats or destroyers, are exciting the ridicule of those foreign nations which, from experience with them, know what submarines are like. We claim that our specially rigged spar torpedo can reach a submarine at a depth of 10 feet below the surface. Commander W. W. Kimball, U. S. N., says[4] very justly, "Why a submarine should run at 10 feet instead of 30 feet or 40 feet does not appear; nor does it appear how the destroyer could, when the submarine showed for a few seconds, head for her, and strike her with the spar torpedo before she attained a safe depth. While the battleship, protected by the destroyer, is the proper quarry of the submarine, there seems to be no law against sinking the destroyer in passing, if her presence were inconvenient." The truth seems to be that, if the submarine can be reached at all by the spar torpedo, she can—at least in the vast majority of cases—be reached much more expeditiously and certainly by means of the gun; though it may be desirable to mount guns in a special manner in order to deal with her.

The offensive usefulness of speed has, I believe, been doubled or trebled by recent improvements in wireless telegraphy[5]. It looks as if every ship, large or small, in future naval warfare might be, as it were, the mobile terminus of an unlimited number of aërial cables communicating not only with the base on shore, but also with all friendly ships within a radius of several hundreds of miles.

It is true that last year, when wireless telegraphy was employed by one side during the naval maneuvers the system broke down, for the reason that the rival commander was able to tap the messages, and did not use wireless telegraphy himself. But the breakdown on that occasion was due entirely to the manner in which wireless telegraphy was misused. The defeated commander might either have employed a code for the sending of his messages, or have used some variety of wireless telegraphy which was not tapable. It is merely a question, on the one hand, of a special cipher, or, on the other, of special discharge terminals, coherers, and relays[6]. The possible variety is infinite; and it is hardly conceivable that in war time the cipher of one side should be known to the other, or that both sides should use exactly similar instruments, similarly "attuned."

Given a good and untapable system of wireless telegraphy, utilizable over long distances at sea, naval strategy, barring accidents, must rapidly become almost an exact science. But it is desirable to have in reserve some alternative to the lofty spars which at present seem to be favored by Mr. Marconi. They cannot be carried by any vessel in very heavy weather; and they cannot be carried by a small craft, such as a torpedo boat or a steam launch, in any weather. It ought to be possible to substitute for them, when necessary, kites[7], such as, I believe, were successfully used by Gen. Baden-Powell at Mafeking. These have much greater radial "command" than can be given to spars on board ship, and they can be flown by craft of all sizes. Electrical kite-flying, and wireless telegraphy by that means, should be part of the ordinary routine of every ship of war. Nor must it be forgotten that there is yet much to be learned with regard to kites, especially kites large enough to carry with them a small motor controllable from below.

We have seen in South Africa that, assuming good intelligence to be at the disposal of a belligerent, the essence of effective practical strategy is extreme mobility—extreme speed, that is. I rejoice, therefore, though it is perhaps hardly even a straw to show which way the wind blows, that the admiralty has decided to continue its experiments with turbine propellers in destroyers, and also to apply the turbine principles to propulsion to one comparatively large vessel, a third-class cruiser. I trust, too, that Whitehall has already devoted its attention to Mr. J. T. Marshall's new valve gear, for there can be no doubt that we must witness, within the next few years, an enormous increase in the speed of large fighting ships; and, then, woe betide the power which lags behind its rivals in the matter of rapid mobility. It will see itself condemned to forego strategy altogether in its naval combinations—in other words, it will find itself confined to the local defensive.

As regards tactical factors, what I have said as to our habitual attitude to new inventions applies more perhaps to them than to strategical factors. Take, for example, the question of range-finding[8] in action at sea. I was once in one of his majesty's ships in which a set of range-finding instruments was fitted experimentally. The appliances were rejected without undergoing a really fair trial. They were tried superficially by people who knew next to nothing about them; and they were condemned, not, so far as I could ascertain, because they were ineffective, but because they were complicated, and could not, of course, be worked easily by the untrained intelligence which was available to handle them. Surely it would have been better to adopt the invention, which had been well tried abroad, or some superior one, and to train the necessary intelligence.

In the meantime, how does our navy hope to find the range in action? It depends mainly upon being able to note the drop of tentative shots[9]. Where two single ships are engaged, this method, though slow and unscientific, may possibly work; but when whole fleets are engaged, how can any human eye feel certain whence comes the particular shot the drop of which is noted? At Santiago it was found to be impossible to form any correct conclusions in that way. Now there are many excellent and almost perfect range-finders. I will mention only the Barr and Stroud, which is said to be responsible for the recent excellent shooting of the "Terrible[10]," and the Zeiss stereoscopic[11], each of which reduces the possibility of error to a minimum, though there are others almost equally as good. For years we have been flirting with such inventions; for years we have refrained from taking them to our arms, because of our fear that we do not sufficiently understand them. They ought to have been long ago in all our fighting ships. By this time we should have learned to understand them. Other nations have adopted them. What will happen if we fall into a conflict with one of those other nations?

Naval gunnery will also be greatly improved so soon as two or three comparatively small problems which are now awaiting solution shall have been solved. Their solution ought not to be long delayed, if only the right kind of intellects can be persuaded to turn their attention to them. The great want of the day is, of course, an arrangement whereby it shall be possible to fire a projectile through moderately thick modern armor, and to burst it immediately in rear[12]. Another great want is some new method of igniting smokeless powders[13]. These powders, especially when fired in relatively small guns, are, as their name implies, practically smokeless. But at present the most convenient method of igniting them is found to be through the medium of an ignition charge of black powder of the old smoky kind. In small weapons the ignition charge, and the quantity of smoke produced by it, are insignificant; but in the case of heavy guns the ignition charge alone comprises about as much black powder as formerly would have sufficed for a couple of full charges for the old 64-pounder muzzle-loader; and, the volume of smoke thus produced being very considerable, the advantages of employing smokeless powder are to a large extent neutralized.

A very noteworthy development of recent science, and one that cannot fail greatly to influence the tactics of future naval warfare, is the modern submarine[14]. I am not a submarine enthusiast; but it is impossible not to recognize that the extension of the open field of naval operations from a space of two dimensions only to one of three is too significant to be lightly regarded. The best existing submarine is very slow, very blind, of limited radius of action, and very liable to accident; but it is vain utterly to deny the value—especially the moral value—of a craft which, without leaving your immediate vicinity, can move altogether out of your sphere of activity, and still, perhaps, deal you a fatal injury. It seems to me that the submarine, even if it be carried no further than at present, means the doom of the old-fashioned blockade.

But I am sure that the submarine will be carried very much further than at present, and that already we may see traced out before us the lines along which it is destined to develop.

The weakest points of the best existing submarines are: That they cannot see clearly unless they come to the surface to do so; that they cannot be sure of maintaining a given course under water, even by utilizing the Obry apparatus[15]; and that the lives of the crews within them are exposed, especially in war time, to extreme risks.

During the past three or four years numerous ingenious inventors have turned their attention to this subject[16] with a view to producing a vessel which shall be capable of moving at considerable speed beneath the surface of the water; which shall not need a human crew; which shall not want to see whither it is bound; which shall be controllable at every moment of its course; shall not expose those who work it to extra-

[1] Institution of Naval Architects.

[2] The Engineer, October 26, 1900; Army and Navy Journal, November 10, 1900; SCIENTIFIC AMERICAN, November 24, 1900; Journal of R. U. S. I., November, 1900; Morskoi Sbornik, May, 1900; Mittheilung, February, 1901; Steamship, March, 1901.

[3] Proceedings of United States Naval Institution (Notes), June and December, 1901; The Engineer, May 10, 1901.

[4] Proceedings of United States Naval Institution, December, 1901.

[5] Army and Navy Register, March 17, 1900; Electrical Review, March 14, 1900; Iron Age, August 23, 1900; SCIENTIFIC AMERICAN, September 8, 1900; SCIENTIFIC AMERICAN, October 20 and November 10, 1900; Steamship, November, 1900; SCIENTIFIC AMERICAN, March 9 and March 30, 1901; Baltimore American, May 8, 1901; Army and Navy Journal, May 25, 1901; Army and Navy Register, April 20, May 11, and June 1, 1901; Yacht, July 6, 1901.

[6] Engineering, May 17, 1901.

[7] Journal of United States Artillery, November and December, 1900; SCIENTIFIC AMERICAN, October 13, 1900.

[8] Proceedings United States Naval Institution, December, 1900; SCIENTIFIC AMERICAN, November 17, 1900; Journal Royal United Service Institution, September, 1900; Army and Navy Journal, January 19, 1901; Proceedings United States Naval Institution (Notes), June, 1901; The Engineer, March 29, 1901; Proceedings United States Naval Institution, September, 1901.

[9] Proceedings United States Naval Institution (Notes), March, 1901.

[10] The Engineer, January 25, 1901; Army and Navy Gazette, June 29, 1901.

[11] Notes on Naval Progress, July, 1900.

[12] The Engineer, June 1, June 15, and June 29, 1900, August 2, 1901; SCIENTIFIC AMERICAN, July 21, 1900; Army and Navy Journal, June 23, 1900; Marine Engineering, October, 1900; Mittheilung, March, 1901; Proceedings United States Naval Institution (Notes), June, and (Alger) September, 1901; Engineering, August 9, 1901.

[13] Army and Navy Register, October 20, 1900; SCIENTIFIC AMERICAN, September 1, 1900; Proceedings United States Naval Institution (Notes), March, 1901; Engineering, May 31, June 7, and July 5, 1901.

[14] Steamship, April and May, 1900; United States Gazette, May 19, 1900; Army and Navy Register, October 13, 1900; Marine Engineering, October, 1900; Army and Navy Journal, January 12 and March 23, 1901; Army and Navy Register, February 9, 1900; The Engineer, January 18 and 25, February 1, March 1, and March 8, 1901; Army and Navy Journal, September 7, 1901.

[15] Engineering, April 12, 1901.

[16] SCIENTIFIC AMERICAN, May 12, 1900.

ordinary risks; and which shall be manageable from a distance without the intervention of wires or other visible connections. It is sought, in a word, to combine the useful features of the existing submarine, of the automobile torpedo, of the electrical countermining launch, and of the Brennan torpedo; dispensing, at the same time, with material ties between the operator and the weapon, and securing a range, which, though less than that of the submarine, shall be far greater than that of the countermining launch, the Whitehead, or the Brennan. Some scores of patents bearing upon these projects have been issued to Messrs. Axel Orling and James Tarbotton Armstrong[17], Arthur A. Govan, Cecil Varicas[18], and Bradley A. Fiske, the last-named being the well-known American naval officer who is famous in connection with more than one range-finder, and with other inventions designed to influence the future of naval warfare.

These gentlemen utilize various forms of energy in various ways; and it is impossible here to go into details of their inventions. It must suffice to say that, although no perfect form of vessel controllable by wireless currents—a form to which I have ventured to give the generic name of "Actinaut"—has yet been produced, more than enough has been accomplished to demonstrate that what it is sought to effect can be effected and will be effected in the near future. Indeed, if it were possible to induce these rival inventors to combine and co-operate, and if it were possible to place at their disposal the knowledge and experience of half a dozen men such as Lord Kelvin, Sir Hiram Maxim, Mr. Brennan, and Mr. Marconi, I verily believe that you might have the perfected engine before you on this day next year. When that perfected engine is produced it cannot fail to work something like a revolution in naval warfare.

All these considerations bring me back again to one of the points from which I started. Our best available tools are rapidly getting beyond the effective control of our best available men, and the real lesson of the situation undoubtedly is that if we would properly utilize all the resources which science has placed, and will presently place, at our disposal for the prosecution of naval warfare, we must greatly improve the scientific standard of the *personnel*.

It is significant that Lord Charles Beresford, without committing himself to any expression of opinion as to the merits of certain types of water-tube boilers, has hinted his belief that many of the breakdowns of those boilers may possibly be attributable, not so much to defects inherent in the boilers, as to the incompetency of the working staff, an incompetency due to lack of training and experience, and perhaps also to short-handedness.

The present Board of Admiralty is admittedly anxious to make the naval service all that it should be; nor does it resent friendly criticism. I would therefore ask their lordships to reflect whether the present methods of dealing with the scientific problems and daily work of the royal navy can possibly produce satisfactory results.

There are two categories of scientific officers in the service—the engineers proper, and the specialist executive officers. The engineers are men with a relatively long, broad, and deep scientific and technical training. They are an expensive class, and at present the navy has confessedly failed to attract and retain the best specimens of the class.

The specialist executive officers are, so Mr. C. M. Johnson, R. N., has irreverently said[19], "Men who dabble in electricity, fiddle about with files and hammers, set up amateur lathes in their cabins, and imagine that they are making engineers of themselves." I do not associate myself with this description of a class of officers who, no matter what else may be said of them, are remarkably keen, and do their work astonishingly well, so far as the conditions permit. But the conditions do not permit much. A torpedo-lieutenant generally gets about seventeen months of technical training in the course of his career. This is, naturally, not enough to make a well-equipped electrical engineer of even the most brilliant of men, still less is it enough to make of him a mechanical and hydraulic engineer as well.

Nevertheless, with a view, I suppose, to economizing expenses, and to restricting the total number of commissioned officers carried, the Admiralty has intrusted a great many purely engineering duties to specialist executives, and in addition, has turned over the entire control of the engineering department in small ships to a warrant officer—an artificer engineer. Not only is this officer of necessity a man of limited education and experience, but also he is now a man less experienced than his fellows formerly were; for a lowering of the standard of qualification has recently been sanctioned.

In the meantime, to assist the specialist executives, a class of ratings known as electrical fitters has been lately called into being. This is composed of men who have very little electrical knowledge at all.

And so we see that whereas at one time all the engineering business of the ship was in the hands of properly qualified engineer officers, much of it is now intrusted to specialist executives, much to warrant officers, and some to people admittedly possessed of hardly any scientific training at all.

While, in short, the *matériel* has been improving yearly, the *personnel* has been assuming more and more the character of a penny-wise-pound-foolish makeshift. This state of affairs must, I think, be remedied if we would profit fully by recent scientific developments. The brightest scientific intelligences ought to be attracted to the navy, and to be retained there when once they have been engaged; and I see no reason why they should not be. We are now paying 5s. a day in South Africa to soldiers—men whose necessary qualifications are little higher than those of unskilled laborers. It can hardly be doubted that a first-rate naval engineer officer, even if you have to pay him a thousand a year, is a much cheaper article than an Imperial Yeoman at £91 5s. Moreover, while you can pick up the latter at any time, you can secure the former only if you engage and train him at a time when, as at present, you are sorely tempted to do without him, and intrust his work to an amateur.

[17] New Liberal Review, June, 1901; Army and Navy Journal, November 16, 1901.

[18] SCIENTIFIC AMERICAN, February 16, 1901.

[19] Discussion on Mr. D. B. Morrison's paper before North-East Coast Institution of Engineers and Shipbuilders, February, 1902.

TORPEDO BOAT DESTROYERS.*

By S. W. BARNABY.

So much attention has been drawn to the destroyer class of the British navy during the past year, that no excuse is needed for a short paper on the subject. It will necessarily be short, because no full treatment of the question is possible, in view of the fact that a committee is now sitting at the Admiralty, and is investigating all the cases in which defects due to weakness of construction are reported to have developed during service at sea. I shall not therefore attempt to discuss these cases, because the facts have not been authoritatively made known. Neither do I wish to express an opinion as to the loss of the "Cobra." I will only say that, although she was an exceptional and experimental vessel, still, if we are to believe that no injury to the bottom preceded the accident, it must be considered surprising that no preliminary straining or laboring of the joints gave warning of danger. We have no experience of mild steel, of the high quality to which we have become accustomed, having failed suddenly, even under repeated applications of stresses well within the elastic limit of the material; but as to what really happened, the evidence, to my mind, is not at all conclusive.

The problem which was originally set the destroyer builders was to produce a small vessel which would be faster than a torpedo boat and would carry a heavier armament. Those were the sole conditions imposed. Messrs. Yarrow and ourselves, who made the first designs, naturally worked on the lines of the torpedo boats which we had been building for years. Speaking for ourselves, we had confidence, from our experience with these boats, that if destroyers were developed on the same lines they would be at least as seaworthy as torpedo boats, if not more so. We had built over 200, some of which had made voyages in all weathers and to all parts of the world, and not one had been lost at sea through insufficient strength. We considered that they must be amply strong to live through any weather in which they might be caught, but that the officers and men might reasonably be asked to submit to the same amount of discomfort at sea as was borne by the crews of torpedo boats, seeing that they were designed for the special purpose of catching these boats.

The torpedo gunboat of 800 or 1,000 tons is probably the smallest vessel in which any degree of comfort for the crew can be secured when it is necessary to remain constantly at sea; but although the torpedo gunboats may be able to overhaul torpedo boats in rough weather because of their size, a class was wanted which would overtake them in any weather, and I think this want has been met by the present destroyers. So far as I know, this condition of discomfort has been cheerfully accepted by the navy, and the important question is, Can these small vessels of high speed be made reasonably safe at sea? I think there is no doubt that they can. The strains coming upon a ship among waves are not exactly, or even approximately, calculable. The effect of the inertia forces produced by the rapid motion of the ends of the vessel as she pitches and scends cannot be estimated, because the velocity of the motion of the parts is not determinable. It is not necessary to enumerate the complex forces produced by the motion in a seaway; it is sufficiently evident that the data for exact calculation are altogether wanting. Then, again, while at one moment the deck of the vessel forms the top of the girder and the keel the bottom, at the next moment the rolling of the vessel may make the corner of the deck take the place of the top, and the opposite bilge that of the bottom of the girder. All that is possible to do is to establish a scale of comparison by which we may judge of the safety of one vessel by comparing her with another which has shown no sign of distress during the time that she has been at sea, and even then it is always possible that exceptional circumstances may occur which may cause us to modify from time to time our standard of comparison.

It is usual to suppose that by considering the vessel first as poised upon the summit of a wave of her own length, and then as lying between the crests of a pair of such waves, and reducing the hull to the form of an equivalent girder, that a method of comparing the stresses to which ships are subjected at sea is possible. The vessel may never be in such a condition, probably never is, and if she were, the stresses would doubtless be different from what they are calculated to be; but in default of a better way of ascertaining if a given ship stands at least as good a chance of safety at sea as some other ship which is proved to be satisfactory, the test is a valuable one. It is usual to assume the height of the wave for vessels of this size as about one-twentieth of the length, and some idea of the severity of the supposed conditions may be obtained when it is stated that it means that a 210 foot destroyer is immersed to the gunwale at the two ends, and that only about $2\frac{3}{4}$ feet of the depth of the hull amidships is in the water when she is lying in the trough; and that when poised on the crest, about 34 feet of each extremity of the ship is out of the water altogether.

It is, of course, of great importance that the deck should not only be sufficiently strong to avoid buckling locally under compressive strains, but that the form of the deck, as a whole, should be rigidly maintained. In the long machinery compartment, where there are no bulkheads, either transverse or longitudinal, great care needs to be taken that the deck beams and longitudinal deck girders are sufficiently strong for the purpose. In some of the latest destroyers built abroad, where the engines are placed between the boilers, the coal bunker bulkheads are continuous through the engine room, and greatly add to the strength amidships, but this arrangement obliges the engines to be placed one in front of the other, since there is not sufficient width for them to be abreast. This so greatly adds to the length of the ship, and consequently to the bending moment, that it is, to my mind, a doubtful advantage. The longitudinals and deep beams over these spaces will no doubt be reinforced in boats in which any tendency to bending has been observed. I think that they might with advantage be further supported by pillars, in order to strengthen the deck to withstand the compression to which it is subjected under a sagging moment. Our practice has been to make the deck perfectly straight for the greater part of the length of the ship, giving no sheer except at the bow. Any sheer amidships prevents the deck from taking its proper share of the tension coming upon the upper works under hogging moments, and throws undue stress upon the sheer strake.

One of the most important factors determining the strength or weakness of a destroyer—more important, in my opinion, than the thickness of the plating—is the ratio of depth to length. In the "Albatross," which is the longest we have built, there are $15\frac{1}{4}$ depths in the length; but in some of the class, I believe, the depth is much less in proportion. Two destroyers may have the same scantlings of plates and frames, and be alike in length and displacement, and yet one may be a weak ship and the other a perfectly sound one; and especially may this be true if there is a great disproportion in relative depth.

As regards details, to which we attach great importance, I will only mention one or two. Unless the greatest care is taken in leveling the shell and deck plating by hand upon the slab, parts of the plate will be more severely strained than other parts, and the strength of the whole plate will thereby be reduced; but this is an operation requiring great skill and taking much time. No amount of machine rolling will level these plates as they require to be leveled if the full advantage is to be taken of every pound of the material. Joggling the butts of deck platings is, in my opinion, an undesirable practice, especially when this is of high tensile steel. I think it not only injures the plates to treat them in this way, but it also prevents the full tensile strength of the plate from coming into play. A joggled stringer butt, for instance, is subjected to an unfair pull, which has to straighten the kink in the plate before it can stretch it, and an excessive strain is thrown on the sheer strake.

The riveting is another detail requiring the greatest care, and we never allow this to be done by piecework. The introduction of high tensile steel has made the question of riveting of still greater importance. The value of this material would be much enhanced if rivets of the same strength could be employed; but there are difficulties attending its use, and not much experience has been gained with hard steel rivets up to the present. If rivets, either of mild or hard steel, are riveted cold, they appear to become brittle and treacherous, and our experience has satisfied us that good Lowmoor or charcoal iron rivets are more reliable, and as strong as steel rivets when put in cold. Rivets of small diameter cannot, we believe, be safely put in hot, whether they are iron or steel, because they are liable to waste by scaling in heating, and are cooled so rapidly on being put into the holes that there is not time to properly knock them up before they arrive at a temperature at which hammering is injurious to steel. We therefore prefer iron rivets for sizes up to $\frac{3}{8}$ inch or 7-16 inch, but those of $\frac{1}{2}$ inch or upward might be of steel, and should be worked hot. It may be possible to use high tensile steel for these, if it is certain that its quality is not affected by the heating, on which point more experiments are desirable. The spacing of these rivets could be greater than with iron rivets, and the plate would be stronger at the joint.

The ratio of weight of structural hull to total displacement in destroyers is not unduly light, and does not compare unfavorably with that found in other classes of warships. For example, Sir William White, in his "Manual of Naval Architecture," gives the weight of material contributing to structural strength in a steel-built first-class battleship of the present day as 18 per cent of the total displacement, and for a typical swift protected cruiser of high speed, large coal supply and heavily armed, as $20\frac{1}{2}$ per cent of the total displacement. This is considerably less than the percentage of weight of material contributing to structural strength in torpedo boats and torpedo-boat destroyers. Although the Thornycroft destroyers are not longer in proportion to depth than the earlier torpedo boats, we have taken more care to preserve the continuity of longitudinal strength than was done in those boats. Continuous keelsons, side stringers, and deck stringers have been introduced which were not fitted in the torpedo boats, and far more attention is now paid to the fitting of doubling plates in way of openings in the deck, such as funnels, fan cowls, hatchways, etc., in order to compensate for the material cut away by these openings, and thus to bring the strength there up to that of a normal section taken through the rivet holes at a frame, which should be the weakest section in the ship. To this question of compensation the Admiralty have very properly attached great importance in all their recent specifications, and there is no doubt that it is much more necessary to pay careful attention to it than it was in torpedo boats, on account of the increase in dimensions.

The longitudinal bending moments for similar ships on similar waves vary as the fourth power of the linear dimensions, so that the stress per square inch of material will increase with increase of dimensions if weight of hull vary as displacement, and as a rule this is found to be the case. Large ships are usually more highly stressed than small ones. M. Normand and others have shown that structural weights should vary as the four-thirds power of the displacement for equal stresses under longitudinal bending in similar vessels. But in dealing with moderate increases of dimensions, as in passing from a torpedo boat to a destroyer, there are a good many of the scantlings, such as plating over propellers, doublings and chafing plates in way of anchors, coal bunker bulkheads and shoveling flats, and other parts which do not count for much in structural strength, but which require to be of a certain minimum thickness for local strength in the smaller vessel, and which do not need to be increased in the same proportion as the rest. The weight thus economized can be utilized in thickening the deck, keel, and sheer

* Paper read before the Institution of Naval Architects.

strake amidships above their proper proportion, and thus the stresses per square inch of material do not rise at the rate that they would otherwise do. As a matter of fact, we have found that by improvements in structural detail, such as I have mentioned, it has been possible to keep the estimated stresses in a seaway down to a figure which allows a good factor of safety, taking into consideration the strength of the high tensile steel employed.

There is no reason why boats having speeds of 30 or 31 knots at light draught should not be as capable of living through bad weather as a torpedo boat. This was the original standard; and provided that they are equally well proportioned and equally well built, they should run no greater risks than their prototypes did. If a higher standard of strength than this is now considered desirable for destroyers for the British navy, so that instead of working from a base they may always accompany the fleet at sea, I believe this requirement can be met without a great sacrifice of speed. It would be unfortunate if the exaggerated impression which has got abroad as to the frailty of destroyers as a class should lead to a swing of the pendulum in the direction of increase of weight which should greatly exceed the necessities of the case. If we go to such heavy scantlings, or if we so increase the dimensions in order to secure comfort at sea, that destroyers can no longer be fast enough to overtake torpedo boats in smooth water, would not their usefulness be much impaired? Other nations will probably continue to build small fast craft of this description, in which comfort is sacrificed to speed and efficiency, and can we afford to be left behind?

The present destroyers, like the torpedo boats, are lightly built at the ends, and it is necessary to give special attention to the bow plating and framing in new boats, so that they may be able to maintain speed in rough water. Besides the local strengthening of the bows and a moderate increase of scantlings generally—say from 10 to 15 per cent—to enable them to stand more knocking about, I think it would be wise to increase the ratio of depth to length even above that of the "Albatross." The strength should then be ample for all requirements. I do not feel at liberty to say anything about the latest designs that have been called for by the Admiralty, in which builders have been left, as usual, a fairly free hand. The moderate speed specified, 25½ knots, is due chiefly to the conditions of trial, which has now to be made with full load on board, and not, as previously, with a very light load. Although I should have preferred to see the trial made under average conditions of load, that is, in fully equipped condition, but with bunkers half full, rather than in either of the extremes of loading, still I can see no reason why thoroughly good boats should not be built under the new conditions laid down, provided that moderate views are allowed to prevail as to the hull weights and dimensions which are left to the judgment of the designer. They will not be as fast at a light draught of water as the present boats are in that condition, but their speed will be increasing all the time as the coal burns out, and the average speed should be considerably more than that obtained on trial.

In view of recent events, what is a safe stress upon the material either of the deck in compression or upon the keel in tension? Do our views upon the subject require modification, and, if so, to what extent? Fairbairn found, many years ago, that the joints of an iron riveted girder sustained upward of three million changes of one-fourth the weight that would break it without any apparent injury to its powers of ultimate resistance. It broke, however, with 313,000 additional changes when loaded with one-third the breaking weight, evidently showing, he says, that "the construction is not safe when tested with alternate changes of a load equivalent to one-third the weight that would break it." There are numbers of large ships at sea in which the stresses must be considered very high if judged by this standard, but which have shown no signs of distress. This would seem to indicate that the extreme conditions assumed in the stress calculations are very rarely met with, and that if they do occur, they last for a comparatively short time. But we have to remember that it is more difficult to get a thin plate to stand a compressive strain than a thick one, and also that small vessels are likely to encounter waves which will strain them more frequently than large ones. The waves which are assumed in stress calculations of battleships are given by Sir William White as 383 feet in length, and 24 feet in height; while those assumed for a 210-foot destroyer are 10½ feet only. Of course, the destroyer which has to keep company with a battleship may be called upon to encounter the 24-foot waves; but these, on account of their greater length, do not produce such a severe bending moment as the smaller wave. The boat cannot stretch from crest to crest, and is better supported than upon the shorter waves of less height. But, as I said before, these calculations cannot be depended upon for exact figures, and are only useful as methods of comparison.

I have my own opinion as to how high a stress it is safe to allow, but it would serve no useful purpose to attempt to fix a definite limit where so much depends upon workmanship and other indeterminate quantities. The builder's own experience should be his guide. If all vessels had to be built to the rules of insurance societies there might be less risk, but there would certainly be less progress; and torpedo boats and destroyers could never have come into existence.

MOTOCYCLES IN 1902.

The motocycle is constantly gaining ground, and, before long, will remain the only representative of the class of cycles actuated by motors. The gasoline bicycle and quadricycle have had their day. Experience has shown that the voiturette is indispensably superior to them, and they will soon disappear, while the motor bicycle will preserve its utility. A proof of this assertion was given at the last Salon de l'Automobile du Cycle et des Sports by the great number of models that were there exhibited.

We shall now pass in review the new types that attracted the attention of the visitors.

The Werner, to which the not unreasonable objection had been made that it was lacking in stability because of the position of the motor upon the handlebar, has been improved. In the model of 1902, the motor is arranged in a much more rational manner, above the crank hanger, and all the details have been more carefully looked after than formerly.

Of the Chapelle, Pécourt, Flinois and Lamaudiere we shall merely say that improvements in details are found therein that render them absolutely practical (Fig. 1). The motor has been reinforced so as to make it possible for it to develop as high as 2-horse power at a great velocity. The carbureter and accessories have been improved, and several models are provided with a speed-changing gear. Let us recall the fact, by the way, that the Werner motocycle figured favorably in the Paris-Bordeaux and Paris-Berlin automobile races. The Chapelle, along with the Cissac machine, triumphed in the mile race to Deauville; the Criterion in the hill race of Gaillon, while the Lamaudiere gave proof of its efficiency in the alcohol race of last November.

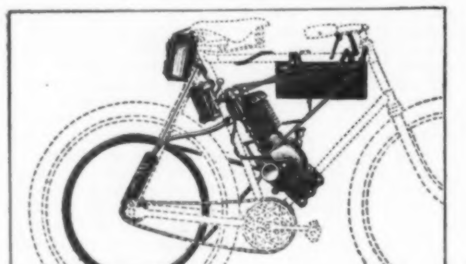


Fig. 1.—AUTOMOBILE BICYCLE, 1902 MODEL.

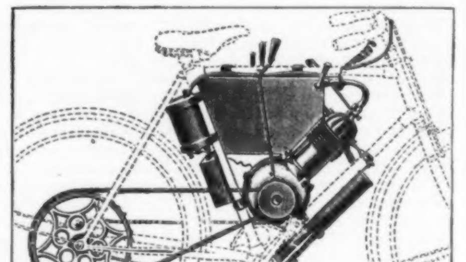


Fig. 2.—BRUNEAU MOTOCYCLE.

Among the new models of the year may be mentioned the Clement, the Bruneau, the Jussy, the Totey, the Ageron and the Leclerc, which we shall examine in the order here given. The Clement autocycle has a movable boiler mounted upon the diagonal tubes of the frame. It weighs, in running order, only about 66 pounds, and yet is capable of attaining a speed of 24.8 miles an hour upon a level. The hind wheel is the driver, and the brake acts upon its felly. The motive mechanism with all its accessories, is applicable to all bicycles, new or old, whatever be their trade name, provided, of course, the frame and especially the front fork be strong enough to withstand the stress of the motor (Fig. 3). The Bruneau motocycle is, like the Werner and Lamaudiere, an automobile on a small scale, and not, like the preceding, a transformed bicycle (Fig. 2). The motor, which is capable of developing one and a half horse power, is placed in the frame and actuates the hind wheel through two sprockets and a chain. As the pedals have been preserved, the machine has two chains as in the Macquart-Vexiau "petrocycle." The carbureter, the accumulator, and the induction coil for sparking are distributed through the frame, and the whole affair is not destitute of elegance. The total weight does not exceed 77 pounds, and the starting may be effected by hand through the intermedium of a friction clutch.

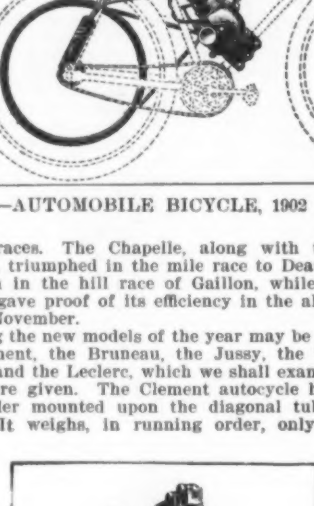


Fig. 3.—MOTOR OF CLEMENT AUTOCYCLE.

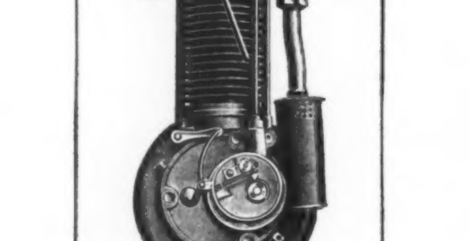


Fig. 4.—THE JUSSY "MOTOSACOCHE."

The Jussy establishment of Saint-Etienne has given the somewhat whimsical name of "motosacoche" to its general arrangement, the motor of which permits of converting any gasoline bicycle whatever into a motocycle in five minutes. Fig. 4 shows the arrangement that has been adopted. The entire mechanism is condensed in a sort of box closed at the sides, like a saddlebag or courier's bag (sacoche: whence the name "motosacoche"), and may be put in place in a few instants.

The Totey model, like that of the Terrot establishment and the Iochum, presents no originality, and there is no necessity of dwelling upon it especially. These three motocycles are evidently derived from the Lamandiere. We find in them, especially, the belt-stretching system that characterizes the latter. We by far prefer the new types of Ageron-Lesprillier and Leclerc (the "Brutus"), which present new and ingenious combinations along with a truly remarkable finish of construction. The "Titania" motocycle of Ageron-Lesprillier is provided with a strong motor of two and a half horse power capable of being set in operation while the bicycle is at a standstill. The throwing into gear is effected after the rider has properly seated himself, and the start is made without any shock. By reason of the power of the motor, any hill whatever may be climbed without pedaling. The "Brutus" does not exceed 17 pounds in weight. It is of inapproachable finish, and its operation is exactly that of the De Dion-Bouton, with a few slight modifications. It is, therefore, well adapted as a motor for bicycles. How it is applied to a machine is shown diagramatically in Fig. 5. Among the types that attracted our attention at the Exposition, must be mentioned the "Française" motor, which is mounted on "diamond" pieces and highly appreciated by cyclists, the Bordes motocycle, which holds the record for lightness (its weight being scarcely 52 pounds) and the "Dayton," an American model, that figured, though not very brilliantly, in the Gaillon race. If, now, we desired to draw a conclusion from our visit to the Automobile Exposition of 1901, at which were brought together so many diverse systems, we should have to recognize the fact, in all sincerity, that the motocycle, after making a very important progress, is capturing the masses. It is *the* democratic and popular automobile par excellence, by reason of its low price and the slight cost of maintenance of its motor; and, after it shall have thoroughly proved its resistance, it will become the queen of the road and its race will multiply, just as ten years ago the humble bicycle actuated by leg-power multiplied.—La Nature.

COMMERCE BETWEEN THE UNITED STATES AND PORTO RICO.

Commerce between the United States and Porto Rico is increasing with phenomenal rapidity, especially since the removal of all tariff restrictions in July of last year. Our purchases from Porto Rico are nearly three times as great as the average during the closing five years of Spanish rule in the island, while the shipments from the United States to Porto Rico are five times as great as the average during the five years preceding the termination of Spanish rule. The receipts of merchandise from Porto Rico at the ports of the United States now range between five and six millions annually, and the shipments to Porto Rico, which were about $7,000,000 in last fiscal year, seem likely to be $10,000,000 in the present fiscal year ending June 30.

This rapid growth in the movements of commerce between the ports of the United States and Porto Rico is presented by a statement just prepared by the Treasury Bureau of Statistics, which shows that the shipments of domestic merchandise from the United States to Porto Rico in the eight months ending with February amounted to $6,887,052, indicating that for the full fiscal year the total shipments of domestic and foreign goods from the ports of the United States to Porto Rico will aggregate about $10,000,000. The exports from the United States to Porto Rico during the five years ending with 1898 averaged less than $2,000,000 per annum, and thus justify the assertion that our shipments of merchandise during the present year to Porto Rico seem likely to be as much as in the entire five years ending with 1898. Over four-

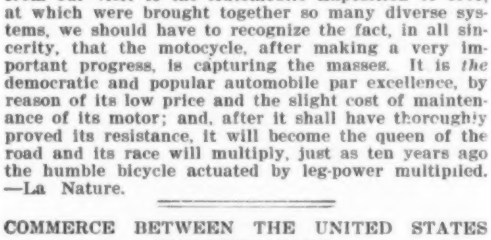


Fig. 5.—BRUTUS AUTOMOBILE BICYCLE.

fifths of the merchandise now brought into Porto Rico is drawn from the United States, and a little over one-half of the merchandise shipped from that island is sent to the United States. The total value of goods shipped from the island in the eight months ending with February was $5,787,619, and of this sum $3,016,258, or 52 per cent, was to the United States. The total value of the merchandise received into the island during the same period was $8,418,078, of which $6,887,052, or 82 per cent, was from the United States.

The following table shows the value of the principal articles shipped from the United States to Porto Rico in the eight months ending with February, 1902, compared with those of the corresponding months of the preceding year:

Articles.	Eight Months Ending with February. 1901.	1902.
Rice	$766,028	$1,109,596
Cotton cloths	723,907	831,271
Cotton manufactures, all other	81,206	673,519
Wheat flour	559,928	657,955
Pork products	455,897	614,563
Machinery, etc.	153,664-	407,223
Other iron and steel manufactures	154,011	279,356
Fish	168,887	208,331
Boards, shooks and lumber	139,632	202,573
Wood manufactures	65,897	168,299
Chemicals, drugs, etc.	53,611	90,025
Beans and peas	23,831	97,223
Dairy products	49,984	88,688
Refined mineral oil	52,635	76,135
Paper, and manufactures of	37,931	71,499
Boots and shoes	28,927	95,108
Malt liquors	34,429	71,441
Books, maps, etc.	24,724	49,280
Cars, carriages, etc.	50,422	52,262
Coal	35,787	45,401
Scientific instruments	21,202	43,668
Steel rails	11,080	57,006
Leather manufactures, other	16,116	38,443
Beef products	38,927	39,734
Other meat products	52,022	60,279
Sugar, refined	10,709	45,938
Wool manufactures	5,315	29,054
Soap	16,571	29,878

THE ARTIFICIAL PRODUCTION OF PRECIOUS METALS.

FOR over a thousand years mankind declared and believed that gold and silver could be artificially produced, and innumerable searchers have labored on this problem. These workers have not been wholly within the class of metallurgists or what we might call scientists, but all ranks and callings have contributed contingents. The general impulse which we designate as alchemy remained influential until the beginning of the eighteenth century, and was so widespread that it deserves consideration by a student of social science. While it is probable that in the more ignorant ages a larger number of people believed in incantations and ghosts than practised true alchemy, yet the public profession of the latter was much more frequent than the public profession of supernatural powers. The history of alchemy has indeed less significance for chemistry than for the history of culture.

The belief in transmutation was promoted by the observation of cases in which the appearance of gold and silver could be imparted to baser metals. For example, copper alloyed with zinc assumes the ordinary color of gold. Treated with certain arsenical substances it assumes a silver-like appearance. Moreover, the doctrine of Aristotle, that substances differ not because of different composition, but by reason of difference of properties, necessarily encouraged the transmutationists. It was in this spirit that one operator distilled mercury seventeen hundred successive times in hopes of driving out from it the liquefying principle and thus obtaining the solid silver.

The ignorance as to the details of chemical composition also led to another misunderstanding. Mine waters containing copper compounds (the existence of copper as such in the water was not recognized) would, by the action of iron, deposit the copper and the iron would dissolve. We have no difficulty to-day in comprehending the nature of the action, but there was a time when it was believed to be a transmutation, and in alchemical language was expressed as being due to Mars (iron) having laid off his armor and decorated himself with the garments of Venus (copper).

It is interesting to note also that according to the Greek alchemists, lead was the generator of other metals. It was especially the generator of silver. We have no difficulty in understanding how this last error arose. Lead ores usually contain some silver, often very considerable amounts, and the operation of cupellation easily burns off the lead and leaves the button of silver, in which small amounts of gold are often found.—Henry Leffmann, in Cassier's Magazine.

A NEW SHAVING PASTE.

EDMUND WHITE writes in the St. Thomas' Hospital Gazette: "A little consideration will show that in shaving it is necessary to support the hairs, so that the razor may cut through them transversely, and at the same time to moisten or lubricate the surface of the skin so that the outer layers of the epidermis may not be too freely removed. . . . . Numerous trials were necessary in order to arrive at satisfactory results . . . and, finally, an emulsion of paraffin wax, melting at 55 deg. C., was adopted. This was prepared with 25 per cent of wax and 2 per cent of tragacanth, the wax being melted and mixed with the tragacanth previously made into a mucilage with some of the water. The addition of a little stearin or lard renders the emulsification of the wax easier, for some reason which cannot readily be explained, while about 10 per cent of alcohol makes the preparation more agreeable to use. The fatty odor of the preparation may be covered by the addition of a half to 1 per cent of lavender oil, and the finished product then appears as a thick white cream. In use a small quantity is rubbed over the area to be shaved and the razor immediately applied. As the water in the emulsion evaporates, the particles of wax previously distributed in the emulsion become coherent and fill up the depressions in the surface of the skin from which the hairs arise, thus forming a mechanical support during the passage of the razor. The quantity required is very small, one ounce being sufficient for shaving the face about six times."

DUBLIN'S NEW CENTRAL STATION AND FIRE ESCAPE.*

TEN years ago, when Capt. Purcell took charge of the Dublin, Ireland, fire department, things were in anything but an up-to-date condition. He steadily devoted his time and brains to bringing the brigade into a new condition, obtaining his information from visits to stations in Europe and America on his own time and expense. With the information thus gathered, he designed apparatus and stations especially adapted to the needs of Dublin. His one great want that has not yet been satisfied, is a central station worthy of his city, and after six years of working his efforts are about to be rewarded. The station will cost about $125,000, and will be a fine structure. It will provide accommodations for the headquarters and working departments as well as for the chief and second officers, twelve married firemen and their families, and apartments for about sixteen single men, with kitchen, dormitories, bath rooms, lavatories, etc. The working department will contain a large engine house with room for five machines, stalls for nine horses, offices and watchroom, reserve stables, workshop, laundry, lofts and gymnasium. A large clock tower will be used as a lookout station and a place to dry hose. The chief's residence will be like a separate house in itself, and those for the men will be separate apartments of ample proportions. The means of access will be by way of external iron stairs and balconies. The floors of the stables and working rooms will be of concrete, of the living rooms of concrete covered with boards. At present the men of the central station are compelled to reside in neighboring tenements, which are in the most wretched condition. In case of fire at night they have to be aroused by messenger. Thus the new station will house the men properly and will afford sufficient accommodations for horses.

It is proposed to change the system of escapes, and, instead of having them in different parts of the city where they have to be watched and are liable to rot and decay, it is proposed to have only four escapes in the city, and they shall be horsed escapes of the most approved pattern. At present the man in charge of an escape is dependent on the service of anyone he can get to help him run the escape to the fire, and is usually exhausted when he arrives, and of no use for fighting. Then, too, the men that are needed to watch the escapes will be available for other work. The situation of the new station is in the heart of the business district, with good outlets in all directions.

One of the new appliances of which Capt. Purcell is very proud is an aerial truck, known to the British as "a swivel-built-radiatory-extension-horsed-escape," built by Rose & Co., of Manchester, from Capt. Purcell's designs. It is intended for narrow alleys, the ladders can be raised by two men before the truck has stopped, and one man can turn them from one roof to another with the greatest ease.

The new escape consists of a series of trussed ladders fitted telescopically, and pivoted at the lower end in a steel turntable, which is capable of being revolved by phosphor bronze gearing within its base. The whole is mounted at the back end of a four-wheeled steel truck, with locking fore-carriage, lever brakes, and pole for two horses. While traveling to a fire the set of ladders lie in an oblique, nearly horizontal position, with a portion of them projecting between the drivers' seats over the horses' backs. When required for use the ladders are raised to the vertical position by means of a flexible steel rope rove through shrouded pulleys at both sides in the outer ends of a rocking frame, which is pivoted to the turntable in advance of the ladders, and led over pulleys in tubular steel stanchions, also mounted on the table, to the winding-drums on a geared winch carried in its base. The turning of a single crank-handle at the back of the truck elevates the ladders, or swings them around into any position by the aid of one man. At the same time, the ladders may be extended to the necessary elevation by the geared winch provided for that purpose. The present set can be made to reach a height of sixty-six feet above the ground. The handles are always in position, and no adjustment is required for operation, everything being ready. Automatic locking devices are provided, so that the ladders will remain up at any angle or height required without attention. A small trussed ladder, fifteen feet long, and a trussed extension ladder to reach twenty-eight feet is also carried in the framing beneath the main ladder and may be removed from the truck for the use of lower floors, courtways, etc., without interference with the

DUBLIN'S NEW ESCAPE OR AERIAL TRUCK.

* By the Special Correspondent of the Municipal Journal and Engineer.

principal escape. Provision is made for carrying a supply of hose and all the small appliances necessary for equipping the brigade.

The ladders are constructed on a new principle, the sides being straight-grained Oregon pine, trussed with weldless steel tubes, neatly mounted in aluminium bronze stanchions, and caps, which carry guide rollers to reduce the friction. The steps are of cleft oak, secured to the sides independently by aluminium sockets of a novel form.

The new escape occupies no more space than an ordinary tender, and may be run under any archway or other overhead obstruction that is nine feet high. A great advantage over the ordinary form of escape, which must have support at the top against the building, is that the new one may be elevated on the street independent of any extraneous support, and used as a water-tower, lines of hose being carried up and directed on the fire in upper floors through the windows. It can also be used to reach ordinarily inaccessible places—under domes, high roofs, etc.

SCALES OF DENOMINATE UNITS.*

By PROF. KELLY MILLER, Howard University, Washington, D. C.

MAGNITUDE may be defined as anything of which greater or less can be predicated. Quantity is a magnitude which can be divided into homogeneous parts.

Arithmetic is the science of numbers, and may therefore be applied to any phenomenon which gives rise to numerical relations.

To measure a quantity directly is to find out how many times it contains another quantity of the same kind, assumed as the standard of measure. To measure a quantity through its function is to ascertain how many times a function of a given stage is contained in the like function of the quantity itself.

The unit of measure is a known (familiar) quantity adopted as the standard of measuring all quantities of the same kind.

With reference to measurability there are two distinct kinds of quantity.

1. A quantity which consists of a group of approximately like individuals is called a discreet quantity. The mind at once seizes upon the individual as the unit of measure for the group. Such a quantity is measured by telling off the individuals one by one, or by counting them, as the phrase runs. The mind, however, demands (approximate) equality among the individual members before it will accept this mode of measurement. Equality lies at the basis of the numerical idea. If Herbert Spencer's primitive savage should bag a hare, a crow, and a partridge, he would keep track of his game by reason of distinguishing characteristics; but should he find himself in possession of a string of fish, of like size and appearance, he could keep run of his luck only by taking cognizance of the numerical value of the bunch.

The mind accepts a member of a group of discrepant objects as a unit of measure only by ignoring individual differences; when we say there are five fingers on the hand we tacitly disregard their discrepant magnitudes. When individual discrepancies become too great to be ignored without conscious effort, the mind refuses to accept any member as the unit of measure of the group. It requires considerable mental effort to count a group of widely dissimilar individuals, e. g., men, horses and birds; and the mind stoutly refuses to accept the result of such counting as an adequate measure of the whole. The unit of discreet quantity is a member of a group of (approximately) equal individuals.

2. A quantity which is not separated into parts is called a continuous quantity. In attempting to measure such a quantity, there is no unit indicated by natural (or artificial) divisions, and we are therefore put to the necessity of devising our own standard. In order to get a clear idea of this subject, we should attempt to divest ourselves of accumulated experiences, and put ourselves in the place of the race before existing scales of units had been devised. If we were called upon to measure the distance between two points, without recourse to the standard units of length, it would be perfectly natural to take as the measuring medium some lengths with which we had become accustomed by frequent use and familiarity. This is but a special application of the general principle of procedure from the known to the unknown.

The measure of continuous quantities gives rise to denominate numbers. Denominate numbers are usually limited to four kinds of quantities, viz., extension, weight, value, and—time. Angular magnitude is sometimes included. These are the quantities of most frequent occurrence in practical affairs of daily life.

The standard denominate units, naturally enough, took their value, in the first place, from familiar quantities of the kind to be measured. The appendages of the human body furnish the units of length, and periodic occurrences indicate the units of time, and the bean, the wheat or the barley grain the units of weight. The inch was taken from the length of the first joint of the thumb, as may be gleaned from the fact that in the French language, both are expressed by the word *pouce*. That the foot was derived from the length of the human foot is implied by the identity of the terms. We have also the evidence of language to show that the yard was derived from the length of the arm. That the word "ell" originally meant arm is seen in the survival of the word "elbow"; that it was also used to designate a unit of length appears from the doggerel:

"Give him an inch and he'll take an ell,
Give him a horse and he'll ride to h—l."

The biblical query, "Who hath measured the waters in the hollow of his hand, and meted out heaven with a span?" indicates quite clearly the primitive mode of measurement.

Time units are marked by periodic changes. The day is the time in which the earth rotates on its axis, entailing a regular succession of phenomena. The year is the time marked by the motion of the earth about the sun. The apparent motion of the sun north and south of the equator gives rise to fairly well-marked intervals called the seasons. These units of time are observed not only by man, but also by the beasts of the fields and the fowls of the air. The month is determined by the career of the moon, as the name clearly indicates. We can again appeal to the unconscious evidence of language to show that time units were marked by the moon which rules by night as well as by the sun which rules by day. The old English word *fortnight* (fourteen nights) is a forcible reminder that the time required by the moon to pass between its extreme phases was once used as a basis of reckoning. The time interval called the week is generally attributed to divine fiat, but indications are not wanting that even this unit was derived from the behavior of the moon. This luminary passes between two fairly well-defined phases in seven days, or rather in seven nights. The fact that our almanacs still use the quarter-moon as a time period, is suggestive of the lunar origin of the week. The smaller units, hours, minutes and seconds, are pure devices. "While the earth remaineth, seed time and harvest, and cold and heat, and summer and winter, and day and night, shall not cease," is the scriptural intimation as to the natural units of time.

Exchange and barter form a prime necessity of society. Value is the worth of anything in terms of some useful object assumed as the standard. There are several requisites of a standard of value: (1) It must represent a familiar and practically constant degree of utility; (2) it must be in general demand and of universal acceptability; (3) it must require a more or less fixed amount of effort to make it available, and (4) it must possess the qualities of stability and currency. It is perfectly natural that cattle should serve as the standard of value among a people in the pastoral stage of development. Aside from the historical evidence, the survival of the descriptive term *pecuniary* (pecus, cattle) is proof enough that cattle were at one time, at least among the Romans, used as the standard of value. It is known that cowry shells, cakes of tea, pieces of silk, pounds of tobacco, wampum, and salt, have been used by different peoples as media of exchange. In all higher civilizations gold and silver have been utilized as the measure of value. They are found to possess well-nigh every requisite of an ideal medium of trade. The wide use of the metallic basis of money precludes the supposition that its origin was accidental or was due to any particular national or individual sagacity. Gold and silver were utilized for monetary purpose by the common sense of the human race.

After the metallic basis had been adopted, there was still need of a scale of units for measuring the basal substance. The precious metals were, in the first place, measured through the function of weight. The Hebrew shekel, the Greek and Roman talent, the Indian carat, and the English pound, indicate the nature of the original units of money. Although various governments have authorized pieces of metals of definite shape, size and degree of fineness as monetary units, nevertheless such units are themselves measurable in terms of weight. A standard measure of the value of one of the precious metals in terms of the other is still a governmental desideratum.

The origin of denominate units should not be without pedagogical suggestiveness. The original units were *familiar* quantities, a knowledge of whose value was forced upon the race by constant observation and handling. The child should be led to form a practical acquaintance with the standard units through the same process.

1. The tables of denominate numbers reveal the fact that there is a scale of units of the same kind, but of different values, for each kind of quantity to be measured. We are thus enabled to apply to a given quantity the unit best suited to its order of magnitude. One would not like to give his age in seconds, nor yet in centuries; neither would it be convenient to express one's weights in grains or in tons. The housewife does not buy sugar by the ounce or spices by the hundred weight. If there were only one unit for each kind of quantity we would be compelled to express values in very inconvenient numbers. The common genius of mankind fights against this restriction, even in abstract numbers by devising the decimal scale, which is only a substitute for different orders of abstract units.

2. As most of these units were of an accidental or incidental origin, it is but natural to expect wide discrepancies among them when brought together for comparison. If the foot is taken as the unit of length, there would be the widest lack of harmony among such units, as any shoe dealer can testify. At a very early stage, the state, or the controlling authority, was put to the necessity of fixing upon some unit and authorizing it as the legal standard. In doing this, however, it can hardly be supposed that the government would deviate widely from the unit which custom had already sanctioned. It is known, for example, that Henry I. authorized the length of his own arm as the standard yard of his realm. It can readily be seen also that different governments or monarchs might not settle upon the same value of like-named units. Even different communities have different values for the yard, the bushel, etc. This foreshadows the necessity of universal standards.

3. The lack of uniformity of relation among the units on any given scale is apparent. The relationship seems to be arbitrary and irregular. The number of inches in a foot affords not the slightest clue as to the number of feet in a yard. This irrelation imposes unnecessary burdens upon the memory of the learner. The irregularity of the scales is due to the incidental origin of the several units. It would indeed be a marvel if the thumb-joint, the foot and the arm-length stood in any simple numerical relation to each other. It is true that statesmanship has established the fixity of the scales, but this was little more than affording governmental sanction to the landmark which custom had set. It would be easy enough to establish the scales where the government might slightly alter the value of any unit in order to bring it into integral relation with the one above or below it, without doing too great violence to the customary values. If, for example, the foot was found to be contained 2 22/23 times in the yard, it would require no radical alteration to slightly decrease the foot so as to make it an exact divisor. We see, however, the bunglesomeness of statecraft in meddling with the laws of nature, in the attempt to harmonize the natural units of time. The week is made a divisor of the month by ignoring a remainder of three days out of thirty-one; the month is made a divisor of the year by making the units unequal among themselves; and the day is made a divisor of the year by an astronomical fiction called a leap-year. A person employed by the month would be accounted insane should he demand his wages at the end of four weeks; and yet he is entitled to the same pay for the months of February, March and April. A year of Februaries would be of the same advantage to the indolent as a month of Sundays; while a century of leap-years would delight the heart of spinsterdom.

4. There are different schemes of units of the same kind. The carpenter, the surveyor, and the sailor measure length according to different scales. Troy, apothecaries' and avoirdupois weights are only different schemes of measuring the same thing. Likeness of name does not connote sameness of value on the different scales. A quart of milk is different from a quart of beans. A pound of salt purchased from the drug-store is one-fifth lighter than a pound bought across the street from the grocer. These discrepant schemes necessarily lead to great confusion. The diversity of scales for measuring quantities of the same nature is due to professional and local causes. The one plan of units is convenient for the surveyor, another for the mariner. Dealers in liquids and venders of vegetables may find it convenient to use different units, although they call them by the same name. The merchant, the jeweler and the druggist may each adopt a scheme of units for reasons of professional convenience.

5. If we turn to the units of value, we see clearly that they depend upon national causes, and can be harmonized only by international agreement.

6. The units of different kinds are arbitrarily connected. The scientific units of surface and volume are not independent, but are functions of the unit of length. But the gallon or the bushel bears no simple relation to the inch or the foot. The side of an acre is incommensurable with all the standard units of length.

If we wish to connect the unit of length with that of weight the difficulty is equally marked. If water is the standard substance of weight, the unit of weight should be the weight of a unit of volume filled with water. But instead, the ounce or the pound bears no simple relation to the cubic foot, the bushel or the gallon.

Most of the difficulties and perplexities existing among the scales of units of extension and weight in vogue among the English-speaking peoples could be eliminated by the adoption of the metric system.

1. The metric units are of a scientific origin, and are everywhere uniform among themselves.

2. The standard unit is based upon the meridian of the earth, and therefore removes the cause of local or national jealousy.

3. Units of like nature bear the simple numerical relation to each other.

4. There is only one scale of units for measuring a given kind of quantity.

5. The units of surface and volume are suggestive functions of the unit of length.

6. The unit of weight is a function of the unit of volume and the standard substance of weight.

Over against these advantages there stand two all-potent countervailing hindrances. (1) The old system has become interwoven in the warp and woof of our language and literature, as well as those of commerce, trade, and daily intercourse, where it defies dislodgement, and (2) *the metric units are not familiar*, and can only be made so by daily use in practical life. The adoption of the metric system has about the same difficulty as the introduction of vertical writing or the revised version of the scripture. Train up a child in the way he should not go, and when he is old he will stick to it. The universal adoption of the metric system would not only simplify the difficulties and perplexities of denominate numbers, but the general interest of the world would be advanced by the adoption of a common measure. Although the difficulties now seem practically insurmountable, yet we may safely predict that the time will come when we shall look upon our present scheme of denominate numbers as a curious barbarous survival.

* Education.

ROENTGEN RAYS IN DIAGNOSIS.

LEONARD (Med. News) says that the use of the Roentgen method is essentially one of diagnosis, and that as such it should be used by professional men only. The diagnostician must possess professional knowledge, special technic and clinical experience with this method. It is often of great service in suspected renal lithiasis, when the typical symptoms are wanting or confused, and a differentiation from diseases of neighboring organs is often impossible by the older methods. The differentiation between renal lithiasis and other forms of nephritic disease is often even more difficult. A small renal calculus may cause symptoms identical with those of incipient malignant or tuberculous disease, and, by blocking the ureter, it often causes anuria and destruction of the kidney. The Roentgen method has shown that calculi in the ureter give rise to renal colic more frequently than when they are in the calices or pelvis of the kidney. This method is of great value in cases of complete obstructive anuria. It often happens that the symptoms are so indefinite even in the case of a large calculus in the calices or pelvis of the kidney, that an absolute diagnosis is impossible except by exploratory operation or the Roentgen method. This method is the only means of differentiating between those cases that demand immediate operation and those in which medical or expectant treatment is justifiable. The chances also of error in the negative diagnosis is very slight, and the calculi that may be overlooked are so small that their final expulsion is certain.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American Trade Methods in Holland.—Mr. S. Calisch, commission merchant at Amsterdam, writes this office as follows, under date of April 4, 1902:

"Some time ago, I asked for an agency for the sale in Holland and colonies of vehicles, harness, and saddles. Although the firm in the United States was not willing to establish an agency, they were inclined to allow 5 per cent commission for all orders sent to them. I received several illustrated catalogues, which I sent to different buyers, being sure that the business could be increased by mediation. I am sorry, however, to say that all catalogues state prices, and that notwithstanding my request for catalogues without prices they sent no catalogues without them. One of their terms reads 'Full amount to be inclosed with order,' and this prevents all business not only in Holland, but, I dare say, on the whole Continent. Up to now, I have had success, and I have obtained some good orders for their articles, which certainly would be followed by larger ones, provided they were inclined to sell on fair terms. For the small commission I cannot take any risk, but am willing to pay half of the order against bill of lading, the other after delivery of the goods. There is no firm that likes to buy and pay the whole amount without seeing whether the goods are delivered as ordered and in good condition."

The objections urged above respecting terms exacted by American manufacturers are so well understood as hardly to justify repetition; yet every consul hears them iterated daily. It is not credit that people here wish—although they are accustomed to that as a matter of course—but a more liberal way of doing business. Cash against documents, or the much more stringent requirement embraced in the foregoing—cash against order—seems to people here to be a sort of stand-and-deliver method of doing things, and is regarded as unreasonable.

But will our manufacturers accord other terms? The representative of one of the largest furniture companies in the United States, recently at Amsterdam, replied in the negative when the question was asked by the writer.—Frank D. Hill, Consul at Amsterdam.

United States Enterprises in Ontario.—The already large list of American concerns having branch establishments in Canada is constantly receiving additions. The American Wire and Steel Company has been incorporated in this country under the title of the Canadian Wire and Steel Company; it has arranged for temporary factory buildings at Hamilton, Ont., and is now running three machines with a capacity of 35 tons daily.

H. R. Lamb, of Michigan, has just established a factory for woven-wire fencing at London, Ont. The Port Huron Engine and Thresher Company, of Michigan, has located a branch factory at Sarnia, Ont., and will employ $500,000 capital in the Canadian and export trade. The plant of the John Abell Threshing Machine and Agricultural Works, Toronto, has been purchased by the Advance Thresher Works, of Battle Creek, Mich. This establishment is said to be the largest of the kind in the Dominion, and has for years supplied many of the machines for Manitoba and the great wheat region of the Canadian Northwest. The object of Americans operating these factories is to avoid the duty, which is so high as to allow little profit on machinery when sent across the boundary line.—E. N. Gunsaulus, Consul at Toronto.

American Shoes in the Netherlands.—During the past six or eight months, there has been a growing demand for American shoes—for men as well as for women. Some manufacturers have introduced their goods with a moderate degree of success, especially in the finer grades. The most popular styles seem to be men's laced and buttoned and women's buttoned shoes. The retail selling prices vary from 4.50 florins ($1.80) to 25 florins ($10) per pair. There is no prejudice whatever against American shoes. The local factories confine themselves for the most part to the manufacture of the cheaper and inferior grades, though in some cases fine shoes are also turned out. The cost of production varies from 2.50 florins ($1) to 7.50 florins ($3) per pair. The customs duty is 5 per cent on all grades and the tare from 3 to 3 1-3 per cent. Some of the local factories contain American machinery, but it is not as successful as it should be, owing largely to the fact that it is operated mainly by inexperienced hands. It is advisable to duplicate the German lasts, for the American lasts are not, as a rule, suited to Dutch feet. Payments are often tardy, but if proper precautions are used, losses rarely occur. Germany and Austria supply the largest quantity of shoes to Holland. The American shoe is far superior, but it is also much more costly. One great drawback to trade has been the long delay in filling small orders, sent to complete numbers which were sold out. The only remedy for this would be the establishment here of a wholesale distributing station, which would also largely develop the sale of the American shoe. This office could dispose of advertising matter, and it would be advisable to have circulars printed in the Dutch language; it would also be of value, if a showroom and distributing station were established here, to advertise in the trade journals.—Frank D. Hill, Consul at Amsterdam.

Trade Opportunities in France.—Shoes.—The American shoe for men is far superior in appearance and comfort to the French article, which is hard and boxy. The former is seldom found for sale outside of Paris and a few of the principal cities. Austria and Belgium furnish the largest part of the imports.

If retail stores under American management were opened in this country, with a wholesale emporium to supply them, a profitable business might be carried on. The greatest difficulty would be the competition of the lower priced French article, which heretofore has kept American footwear from entering this market as generally as it has some other European countries. The tariff on shoes is 1 franc (19.3 cents) per pair; on boots for men and women and on top boots, 2.50 francs (48.25 cents). American fine boots and shoes of all kinds ehter Germany for $15.66 per 100 kilogrammes (220 pounds) and Austria for $14.21. Shoes weighing, say, 800 grammes (1.8 pounds) per pair pay $24.125 per 100 kilogrammes at French ports, a considerably higher tariff than in either of the above-mentioned countries. The lower, or cheaper, grade of American shoe cannot be sold in France.

The French shoe, especially the Norman product, is a distinct type. In this city, there are so-called American shoes exposed for sale, but a glance shows that the French manufacturer has signally failed in his imitation.

Steam Shovels and Dredges.—American firms manufacturing steam shovels and kindred utensils have made inquiries as to the possibility of a market for their products in this district. The only waterway is the Seine, which last winter was supplied with three new dredges of French manufacture. The waterways bill voted last year provides for improvements at a cost of $12,100,000. The project for new canals includes one connecting the northern coal fields with Lorraine, another from the Loire to the Rhone, and a third from Marseilles to the Rhone, at a cost of $88,600,000; and improvements of the ports of Dunkirk, Havre, Nantes, Bordeaux, St. Nazaire, and other places, at a cost of $31,800,000. At present, the number of kilometers of French canals in operation is nearly 5,000, and the length of navigable rivers 7,600 kilometers, making the total length of navigable canals and rivers nearly 12,600 kilometers, or, in round numbers, 8,000 miles.

Stone Crushers.—The French system of public highways, extending to every section of the Republic, is not surpassed by that of any country in the world. All stones are crushed with hammers by hand, the workmen often being seated. It is a long and tedious process. As early as 1867, the improved macadamized highways of France had a total length of 200,951 miles, while the length of unfinished highways was then stated at 174,667 miles, most of which is now finished. But the use of crushed stone is not confined to these roads; it is employed in buildings, in walls, for railroad ballast, etc. If an American manufacturer could secure a small municipal contract, which would permit the utility of a steam stone crusher to be demonstrated in the quarries here, it would, no doubt, bring good results.

Elevators.—While it is true that the French do not erect such tall buildings as Americans, there is nevertheless need for elevators. There are only two in this city of over 150,000 people. Buildings in Norman cities are seldom more than six stories in height, the average, perhaps, being three or four.

Lightning Rods.—Since coming here eighteen months ago, I have not seen a lightning rod. Such a condition, coupled with the fact that Frenchmen favor insurance, would seem to indicate a good field. The article is not mentioned in the tariff schedule, and the duty could be determined only by submitting a sample. It would be almost impossible to sell such goods, however, without personal effort.

Other Articles.—The following articles might also be mentioned, which if not unknown are comparatively little used: Chewing gum, washboards, portable hot-air bath cabinets, oatmeal, hominy grits, corn for table food, molasses and sirup.—Thornwell Haynes, Consul at Rouen.

Opening for Brewery in Para.—Under date of April 7, 1902, Consul K. K. Kenneday writes from Para:

About two years ago, a local company was organized to establish and operate a brewery in Para. A large modern building was erected and a complete outfit of first-class machinery purchased. Then came the financial crisis and the company failed. The machinery and plant lie on the docks of this city, where they were landed, and the building stands idle. The fixtures, machinery, building, and all the other holdings of the company can now be purchased for a mere tithe of the cost—probably 10 cents on the dollar. A quantity of beer is consumed in Para, and it could be increased if the price were less prohibitive. I am semi-officially informed that the city government of Para is ready to place a municipal tax on Rio beer in favor of the local product, if any responsible company will take charge of the Para brewery.

Demand for Liquid Glue in Ireland.—Consul W. W. Touvelle reports from Belfast, April 17, 1902:

From recent investigation, as well as from inquiries that have been made at this office, I am satisfied that a good opportunity is offered American manufacturers for the sale of liquid glue, and especially of liquid fish glue, in Belfast. The manufacture of glue in this consular district is entirely inadequate to supply the demand of the trade. From the Belfast harbor commissioner's report for 1901, I find that 356 tons of glue were imported into Belfast, all of which came from England. Messrs. McCaw, Stevenson & Orr, Limited, of Linenhall Works, Belfast, color printers and publishers of school books, are extensive users of liquid fish glue, and are desirous of having their firm name brought to the attention of manufacturers in the United States.

Inquiry for Rice-Milling Machinery in Siam.—Consul-General Hamilton King, of Bangkok, transmits, under date of March 4, 1902, a letter reading, in part:

"I am desired by Prince Pra Ong Chow Sai Sanitwongse to remind you that you promised to give him full particulars about rice milling in America, if His Highness would state his needs. His wishes are:

"I. To start a rice mill for making paddy to the amount of about 1,000 piculs (133,000 pounds) of white rice a day; the machinery to be driven by electricity.

"II. To know what kind of machinery and boilers would be best adapted to this purpose, as regards the consumption and economy of fuel (fuel here means rice husks obtained from the mill itself).

"Experience with steam rice mills in this country shows that if engines and boilers of the old system are used for making paddy into broken rice only, the consumption of fuel (rice husks) equals about half that produced; and if a condensing engine and a boiler with Galloway's tubes are employed for making a paddy into white rice, the consumption about equals the fuel produced.

"III. The pearling and polishing machines used in this country damage the grains very much, breaking and pounding the rice and rendering it too warm. This polishing process is also generally supposed to spoil the taste of the rice. It is desired, therefore, to know whether there are other kinds of machinery which will perform an equal amount of work and at the same time overcome these difficulties.

"Most people in this part of the world prefer rice pearling by mortar, after the ancient native system. If 'rice pounders' instead of other pearling machines should be adopted, would the output be decreased, and could the objectionable features mentioned be avoided?

"IV. The desire in starting electric rice milling is to run vehicles by the same power. If a rice mill driven by electricity is erected—for instance, the mill mentioned in Paragraph I.—the engines and boilers being the most economical in consumption of fuel that could be provided, would any power be available for other purposes, if rice husks were used for fuel? If so, how much?"

Mr. King adds:

Prince Chow Sai Sanitwongse has for years been the moving spirit in the great Klong Rangsis irrigation scheme of Siam,* which has reclaimed from the jungle hundreds of thousands of acres, converted it into the richest rice-producing area of the country, and provided homes for about 100,000 people in the last ten years. Coming from such a source, the request is worthy the careful consideration of our producers. My previous reports to the Department on "Agricultural machinery in Siam" and "Canals and irrigation in Siam"† will furnish further information on this subject to those who are interested. Any correspondence on this question will receive prompt attention if addressed to me.

Protection of Metallic Tubes in France.—Consul Thornwell Haynes, of Rouen, March 28, 1902, reports that M. Bergier, a Frenchman, has just discovered a composition for protecting metallic tubes against the action of liquids. The composition, says the consul, consists of the following:

	Kilogrammes.	Pounds.
Dry sand	100	= 220.4
Potash or soda	83	= 182.9
Nitrate of potash	2	= 4.4
Minium	15	= 33
Pulverized marble	5	= 11
Dichromate	0.10	= .22
Red oxide of copper	0.05	= .11
Regulus of antimony	0.05	= .11

This is applied to the interior of the tube as follows: The vitreous substance is first blown into cylindrical form and is then introduced into the tube, which has been brought to a white heat, the blowing being continued until the composition adheres to the metal. The consul adds that the composition is claimed to have an expansion and contraction equal to that of the metal which it protects.

Copper in Asiatic Turkey.—Consul T. H. Norton, of Harput, under date of February 24, 1902, reporting the results of a recent trip in the vilayet of Diarbekir, says that the magnificent copper deposits at Arghana Maden, in the Taurus Mountains, are being steadily mined and bring a revenue of over $130,000 to the town. The methods of mining and the smelting processes, however, are the crudest.

Proposals for Electric Pump at Montreal.—Commercial Agent F. S. S. Johnson writes from Stanbridge, April 7, 1902:

An opportunity presents itself to our manufacturers to compete with Canadians in proposals for an electric power pump for the Montreal waterworks. Tenders for the electric pumping engine will be received up to noon on Tuesday, the 6th of May, at the office of the city clerk, City Hall, Montreal, for the erection at the high level station of a 5,000,000-imperial-gallon pumping engine, to be driven by electricity against a pressure of 26 pounds per square inch.

Decree Affecting Cattle Hides at Panama.—Consul-General H. A. Gudger, of Panama, under date of April 7, 1902, says that the civil and military chief of the Department of Panama has issued a decree in which it is ordered that all hides of cattle killed must be immediately turned over to the government.

Demand for Coal-Handling Appliances in Lourenco Marquez.—Consul W. S. Hollis reports from Lourenco Marquez, March 19, 1902, that, in a recent conversation with Senhor Albers, head of the harbor commission, he was informed that it is intended to make that port a great coaling station. Senhor Albers particularly requested to be put in communication with people in the United States who could supply him with the most economical and up-to-date coal-handling appliances, such as trestles, cranes, and machinery for delivering coal from freight cars (3-foot 6-inch gage) into the holds and bunkers of vessels. Any written or printed matter addressed to the consul will be submitted to Senhor Albers.

* See Advance Sheets No. 1300, dated March 27, 1902.

† Advance Sheets No. 636 (Consular Reports No. 234) and No. 1300.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Tooth Powders and Pastes.—

1. Charcoal and sugar, equal weights. Mix and flavor with clove oil.

2. Charcoal .... 156 ounces
Red kino .... 156 ounces
Sugar .... 6 ounces
Flavor with peppermint oil.

3. Charcoal .... 270 ounces
Sulphate of quinine .... 1 ounce
Magnesia .... 1 ounce
Scent to liking.

4. Charcoal .... 30 ounces
Cream of tartar .... 8 ounces
Yellow cinchona bark .... 4 ounces
Sugar .... 15 ounces
Scent with oil of cloves.

5. Sugar .... 120 ounces
Alum .... 10 ounces
Cream of tartar .... 20 ounces
Cochineal .... 3 ounces

6. Cream of tartar .... 1,000 ounces
Alum .... 190 ounces
Carbonate of magnesia .... 375 ounces
Sugar .... 375 ounces
Cochineal .... 75 ounces
Es. Ceylon cinnamon .... 90 ounces
Es. cloves .... 75 ounces
Es. English peppermint .... 45 ounces

7. Sugar .... 200 ounces
Cream of tartar .... 400 ounces
Magnesia .... 400 ounces
Starch .... 440 ounces
Cinnamon .... 32 ounces
Mace .... 11 ounces
Sulphate of quinine .... 16 ounces
Carmine .... 17 ounces
Scent with oil of peppermint and oil of rose.

8. Bleaching powder .... 11 ounces
Red coral .... 12 ounces

9. Red cinchona bark .... 12 ounces
Magnesia .... 50 ounces
Cochineal .... 9 ounces
Alum .... 6 ounces
Cream of tartar .... 100 ounces
English peppermint oil .... 4 ounces
Cinnamon oil .... 2 ounces

Grind the first five ingredients separately, then mix the alum with the cochineal, and then add to it the cream of tartar and the bark. In the meantime the magnesia is mixed with the essential oils, and finally the whole mass is mixed through a very fine silk sieve.

10. Whitewood charcoal .... 250 ounces
Cinchona bark .... 125 ounces
Sugar .... 250 ounces
Peppermint oil .... 12 ounces
Cinnamon oil .... 8 ounces

11. Pumice .... 250 ounces
White coral .... 250 ounces
Cuttle bone .... 250 ounces
Cream of tartar .... 250 ounces
Florence orris root .... 250 ounces
Sal-ammoniac .... 60 ounces
Ambergris .... 4 ounces
Cinnamon .... 4 ounces
Coriander .... 4 ounces
Cloves .... 4 ounces
Rosewood .... 4 ounces

12. Dragon's blood .... 250 ounces
Cream of tartar .... 30 ounces
Florence orris root .... 30 ounces
Cinnamon .... 16 ounces
Cloves .... 8 ounces

13. Red coral .... 250 ounces
Cuttle bone .... 250 ounces
Dragon's blood .... 250 ounces
Red sandalwood .... 125 ounces
Alum .... 125 ounces
Orris root .... 250 ounces
Cloves .... 15 ounces
Cinnamon .... 15 ounces
Vanilla .... 8 ounces
Rosewood .... 15 ounces
Carmine lake .... 250 ounces
Carmine .... 8 ounces

14. Cream of tartar .... 150 ounces
Alum .... 25 ounces
Cochineal .... 12 ounces
Cloves .... 25 ounces
Cinnamon .... 25 ounces
Rosewood .... 6 ounces

Scent with essence of rose.

15. Coral .... 20 ounces
Sugar .... 20 ounces
Wood charcoal .... 6 ounces
Essence of vervain .... 1 ounce

16. Precipitated chalk .... 500 ounces
Orris root .... 500 ounces
Carmine .... 1 ounce
Sugar .... 1 ounce
Essence of rose .... 1 ounce
Essence of neroli .... 4 ounces

17. Cinchona bark .... 50 ounces
Chalk .... 100 ounces
Myrrh .... 50 ounces
Orris root .... 100 ounces
Cinnamon .... 50 ounces
Carbonate of ammonia .... 100 ounces
Oil of cloves .... 2 ounces

18. Gum arabic .... 30 ounces
Cutch .... 80 ounces
Licorice juice .... 550 ounces
Cascarilla .... 20 ounces
Mastic .... 20 ounces
Orris root .... 20 ounces
Oil of cloves .... 5 ounces
Oil of peppermint .... 15 ounces
Extract of amber .... 5 ounces
Extract of musk .... 5 ounces

(To be continued.)

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